PHOTON KINETICS

Model 3100H OTDR
User's Manual

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Revision A

This is the User's Manual for the Model 3100, Model 3100H and Model 3100T OTDRs. The instruments are identical in operation. There is a slight difference between the illustrations shown in the manual and the screen display of a Model 3100, but the operations illustrated will still be recognizable. The only technical difference between a Model 3100 and a Model 3100H is that the 3100H has a plot buffer and the 3100 does not.

Appendices B and C contain information specific to the Model 3100T OTDR. The operation of the Models 3100H and 3100T are the same; only the specifications and one adjustment knob are different.

This User's Manual supersedes any other Model 3100 User's Manual.

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SAFETY SUMMARY

1. OPERATOR'S SAFETY SUMMARY

1.01 The following general safety information is for both operators and service personnel. In addition, specific warnings and cautions are placed throughout both the user and service manuals.

Safety Terms in this Manual

1.02 WARNING statements identify conditions or practices that could result in damage to the equipment or other property.

1.03 CAUTION statements identify conditions or practices that could result in interruptions of service.

1.04 DANGER statements identify conditions or practices that could result in personal injury or loss of life.

1.05 Observe all warnings, cautions and dangers noted in the user and service manuals.

Safety Terms as Marked on the 3100H OTDR

1.06 CAUTION indicates a personal injury hazard that is not immediately accessible as the marking is read, or a hazard to other property or to the instrument itself.

1.07 DANGER indicates a personal injury hazard immediately accessible as the marking is read.

Optical

1.08 The 3100H OTDR with a Model 313H, 315H, 313L, 313M or 628Hoptical plug-in module is a Class I Laser Product, as defined by Federal regulations 21 CFR 1040. A Class I Laser Product is one which emits insufficient levels of laser radiation to constitute a hazard, according to established limits. Despite this, it is good operating practice to avoid direct eye exposure to the output of this product, or to the open end of any optical fiber connected to this product.

1.09 "Caution - use of controls or adjustments or performance of procedures other than those specified may

Electrical

1.10 Power Source: The 3100H OTDR is intended to operate from a power source that does not apply more than 264 volts rms between the supply conductors or between either supply conductor and ground. Refer to Section 3 of this manual for voltage change-over instructions.

1.11 Ground and Loss of Ground: A protective ground connection by way of the grounding conductor in the power cord is essential for safe operation. To avoid electrical shock, plug the power cord into a properly wired receptacle. If this is not done or should the ground connection be lost, all conductive parts of the instrument (including some controls that appear to be insulating) can render an electric shock.

1.12 Power cord: Use only the power cord that was shipped with this product. Order a replacement cord if the original becomes worn or unserviceable.

1.13 Fuse: To avoid fire hazard, use only a fuse of the correct type, voltage rating, and current rating. Refer to Section 3 of this manual.

1.14: Covers or Panels: To avoid personal injury, do not remove the product covers or panels. Do not operate the product without the covers and panels being properly installed.

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SECTION 1: INTRODUCTION

1. OVERVIEW

1.01 The Photon Kinetics Model 3100H Optical Time Domain Reflectometer (OTDR) is a high-performance instrument for single or multimode optical fiber testing. Applications for the Model 3100H OTDR include fault location, splice loss measurement, and the characterization of fiber attenuation, uniformity, and length. The 3100H OTDR is a portable, rugged instrument appropriate for field and laboratory applications. Plug-in optical sections allow testing at multiple wavelengths. Distance and loss measurement functions are automated for consistent results. Advanced OTDR technology is used to maximize the range and accuracy of measurements.

Measurement Abbreviations

1.02 The following abbreviations are used throughout this manual:

km = kilometers (1000 meters)
kft = kilofeet (1000 feet)
m = meters (0.001 km)
ft = feet
dB = decibels (optical)
nm = nanometers

Capitalization Conventions

1.03 The names of instrument controls are capitalized within the text, to differentiate them from measurements or instrument modes with the same names.

2. UNPACKING AND INSPECTION

1. Visually check the shipping carton for physical damage. Make note of any obvious mishandling.

2. Remove all items from the shipping carton. If any item appears broken or damaged, notify Photon Kinetics and the carrier immediately to assure proper handling of any claims.

Warning: Do not remove the protective dust cap from the optical connector until you are familiar with the fiber connection procedure. Refer to Figure 2-2, Model 3100H.

3. Hidden damage: If after following the setup and operation procedures detailed in this manual the Model 3100H is not operating correctly, there may have been hidden shipping damage. Notify the Photon Kinetics service department immediately to assure proper handling of any claims.

4. Check to see that the following items are included, as illustrated in Figure 1-1:

a. Model 3100H mainframe with plug-in installed

b. North American AC power cord, or one of the two alternate power cords listed below under Mainframe Options

c. User Manual, data sheet for plug-in, and Optical Connector Usage Guide

d. Lid pouch for accessories

e. Optical Connector Cleaning Kit

f. Soft Transit Case (for optical plug-in)

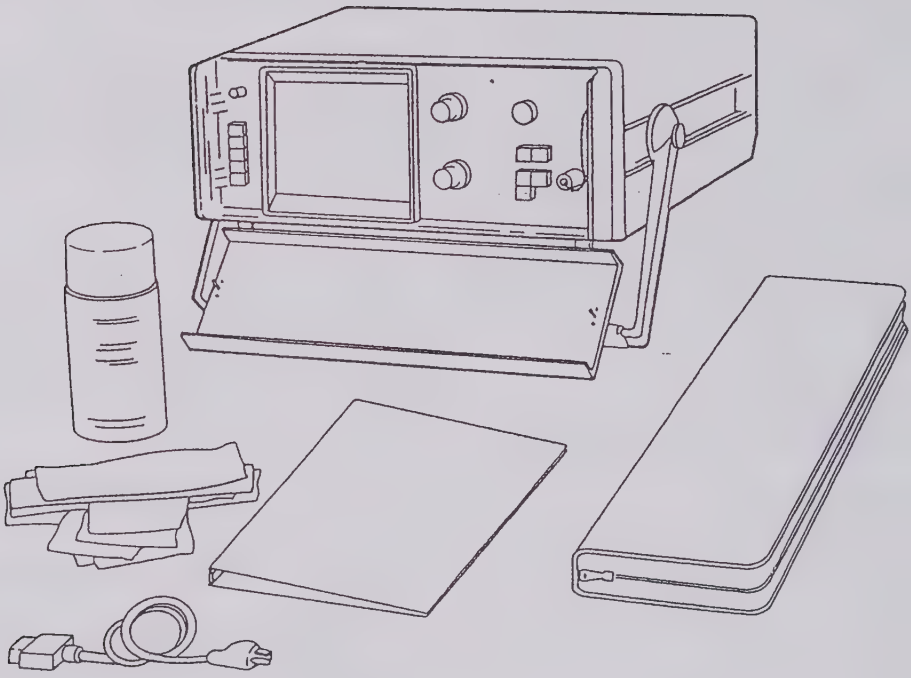


Figure 1-1. Model 3100H OTDR Package.

3. OPTIONS

Mainframe Options

3.01 The following accessories are available. Contact Photon Kinetics for ordering information.

- Universal European 220V power cord
- UK 240V power cord
- 313H 1300nm (21dB range) single-mode plug-in
- 315H 1550nm (18.5dB range) single-mode plug-in
- 313L 1300nm (16dB range) single-mode plug-in
- 313M 1300nm(22dB range) multimode plug-in
- 628H 1300/1550nm (20/17.5dB range) switchable single-mode plug-in
- Hard Transit Case for 3100H
- GPIB cable, 2m (6.6 ft.)
- HP Graphics Plotter
- Hard Transit Case for Plotter
- Soft Transit Case for Plotter

Optical Section Plug-in Options

3.02 The plug-in modules may be ordered with one of the following optical connectors:

- Biconical (single or multimode)
- FC (single or multimode, NTT Standard)
- Diamond (single-mode)
- D4 (single or multimode)
- SMA (multimode)
- ST (multimode)

3.03 Pigtail cables have a connector at one end and bare fiber at the other. They are also available in the standard configurations (ex: FC, D4).

3.04 Jumpers: any connector-to-connector pigtail is also available. (ex: 5 meter FC to Biconical.) Contact the factory for details.

4. TRANSPORTING THE MODEL 3100H

4.01 The Model 3100H is designed to be a rugged, field-portable instrument. However, it should be treated with the same common sense care given to any high quality precision instrument. If frequent transporting or rough handling of the Model 3100H is expected, purchase of the Hard Transit Case is recommended. Refer back to the Mainframe Options portion of this section.

5. RETURNING THE MODEL 3100H FOR SERVICE

5.01 - To return the Model 3100H OTDR for service, call customer support at (503) 644-1960, for a return material authorization (RMA) number. Be ready to state the Model 3100H or plug-in serial number.

5.02 After receiving an RMA number, return the unit to:

Photon Kinetics, Inc.
9350 Southwest Gemini Drive
Beaverton, Oregon 97005

5.03 Ship the unit prepaid in the hard transit case, the original shipping container or equivalent. Show the RMA number on the outside of the container and on the shipping paperwork.

SECTION 2: DESCRIPTION

1. OVERVIEW

1.01 The OTDR is a self-contained unit, with all controls either on the front or back of the unit. The following descriptions will briefly outline the function of each item on the Model 3100H. For operating instructions, refer to Section 3, Operation.

2. MODEL 3100H HARDWARE

1.02 Refer to Figure 2-1 while reviewing the following items on the Model 3100H.

- Transport Handle : The handle can be positioned to form an elevating base for the OTDR.

- Handle Lock Buttons : The buttons on either side of the handle can be depressed to re-position the handle.

- Hard Cover : This metal cover can be lowered or removed while using the OTDR. The adhesive label inside the cover provides a quick guide to making measurements.

- Optical Connector: The optical fiber is attached to the OTDR with this connector. There are six possible connector types for the OTDR: Biconical, D4, Diamond, FC, ST and SMA. One connector is installed before shipping.

- Dust Cap: This cap should be in place at all times when a fiber is not connected to the instrument.

3. FRONT PANEL

3.01 The front panel controls allow the user to make measurements quickly and easily. Refer to Figure 2-2 while reviewing the following items.

1) Intensity Knob: The intensity knob adjusts the brightness of the CRT screen.

2) Plot: The Plot button sends the entire contents of the display to an HPGL compatible pen plotter via the GPIB. In this way, hardcopy records of measurements can be generated. The front panel controls are locked for approximately 6 seconds while the plot buffer fills. Then other measurements can be made as the plotter is working.

3) Local: The Local button returns control to the front panel, aborting the measurement. The Local button also returns the Model 3100H from GPIB remote control to front panel control. As the button is pressed, the GPIB address of the Model 3100H is displayed in the lower left portion of the display. To regain remote control, the GPIB controller must re-establish communication with the Model 3100H. Pressing the Local button a second time will not return the instrument to remote control. Refer to Section 4, GPIB Interface, for general information on GPIB operation.

4) Ref Index : The Ref Index button places the Model 3100H into a mode in which the refractive index setting can be changed. When Ref Index is pressed, the button LED lights and all other controls are temporarily locked out of their normal functions. The Marker knob then controls the refractive index setting, which is indicated on the right side of the display. Pressing Ref Index a second time locks in the refractive index setting and restores normal instrument operation. The instrument maintains the last refractive index value set, even when the power is off. Thus, it is not necessary to reset the refractive index each time the instrument is switched on. The range is 1.400 to 1.700.

5) Fiber Range: This button selects the fiber range - either 50km or 100km. Up to 100 km of fiber can be examined in 50 km (164 kft) sections (12.5 km or 41 kft sections if in Hi Res).

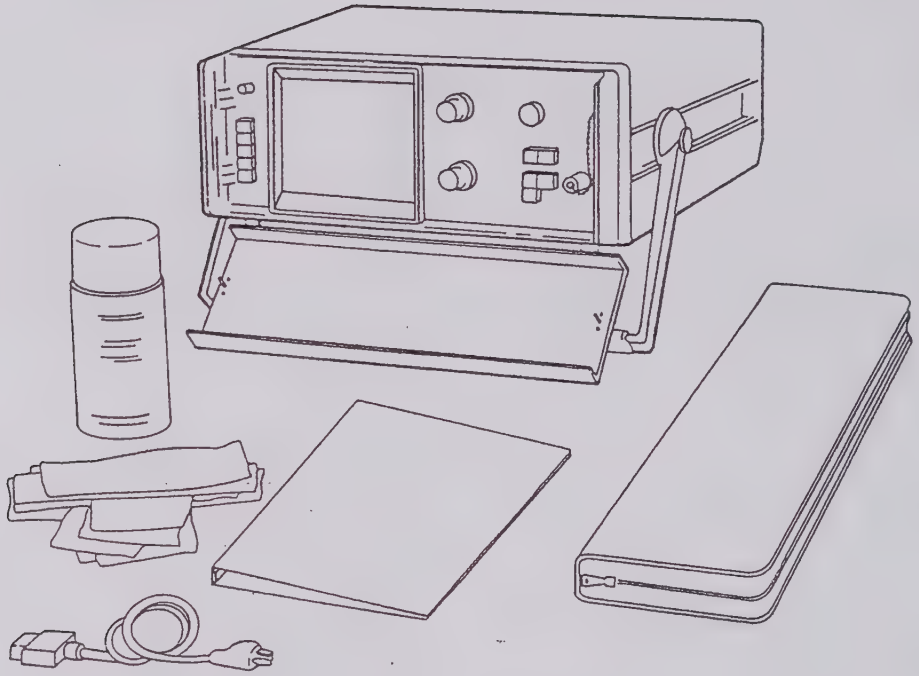


Figure 2-1. Model 3100H.

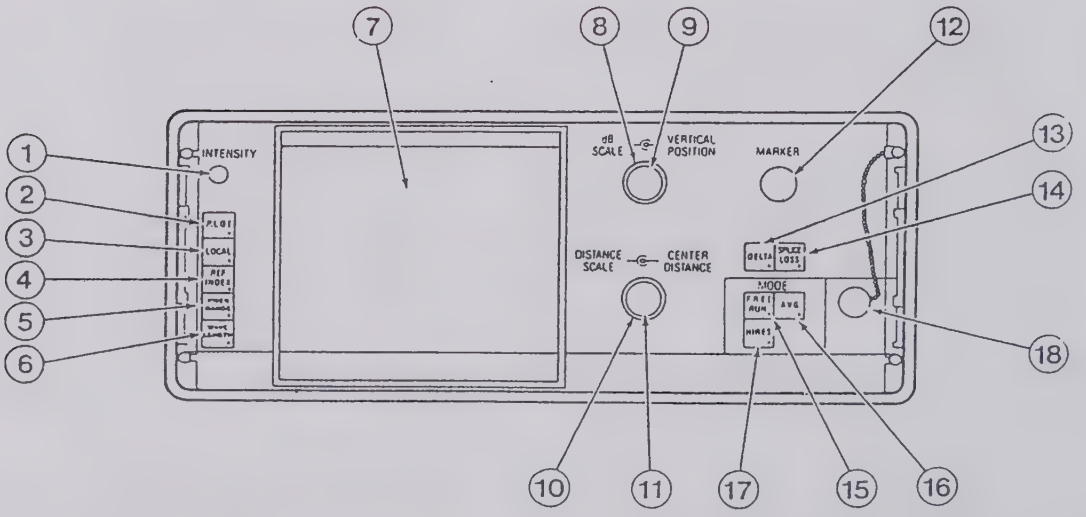


Figure 2-2. Front Panel.

6) Wavelength: This button switches between 1300 nm and 1550 nm, if the 628H plug-in is installed and its switch is set in the middle position. The wavelength can be read in the bottom right corner of the display.

7) Display Screen: For individual display details, refer to Figure 2-3, Typical Display, and its text.

8) dB Scale (outer ring knob): The dB Scale knob controls the vertical magnification of the display window. The range is 5, 1, and 0.5 dB/division of one-way fiber loss.

• This control has no stops. The vertical scale readout on the right side of the display indicates the dB scale setting. The 5 dB/division setting allows the full height of a fiber signature to be displayed. The 1 dB/division and 0.5 dB/division settings allow closer examination of the details in the fiber signature.

9) Vertical Position (center knob): The Vertical Position knob controls the vertical position of the fiber signature. (Clockwise moves the signature up.)

10) Distance Scale (outer ring knob): The Distance Scale knob controls the width of the display window. The 4km/division (13.1 kft/division) setting allows the largest extent of the fiber signature to appear on the display; lower settings magnify smaller portions of the fiber signature.

• The range with Hi Res off is 4 km (131.1 kft), 2 km (6.6 kft), 1 km (3.28 kft), 500 m (1640 ft), and 200 m (656 ft) per division. The range with Hi Res on is 1 km (3.28 kft), 500 m (1640 ft), 200 m (656 kft), 100 m (328 ft) and 50 m (164 ft) per division.

• This control has no stops. The horizontal scale readout on the right side of the display indicates the distance scale setting.

11) Center Distance (center knob): The Center Distance knob moves the display window left or right along the fiber signature. The display window location is indicated on the display window indicator at the top of the screen (Figure 2-3, Typical Display.)

12) Marker: The Marker control moves the marker ("+") across the display, tracking the fiber signature. (See also Figure 2-3, Typical Display.)

13) Delta: The Delta button allows relative distance measurements between two points.

14) Splice Loss: The Splice Loss button initiates both auto and manual splice loss measurements when pressed quickly. When held in, it toggles between auto and manual mode.

• When the splice loss function is active, the LED in the Splice Loss button will be lit. During this time, some of the normal functions of the 3100H are disabled. The Splice Loss function can be turned off by pressing Local.

15) Free Run: The Free Run button provides a real-time display of the fiber signature. The display is updated about five times per second in 50 km (164 kft) range.

16) Avg (Average): The Avg button turns off Free Run, and starts a noise reduction process on the fiber signature. The result is a stored fiber signature, on which precise measurements can be made.

• After Avg is pressed, the noise reduction process will continue for approximately 60 seconds. The process can be stopped at any degree of completion by pressing Avg a second time.

• It is not necessary to stop the averaging process in order to use the other controls to reposition the display window – the display window can be moved while averaging is underway.

• The progress of the averaging process is indicated by a numerical readout in the upper right corner of the display (refer to item 10, Figure 2-3). This readout will count up from 1 to 256, with 256 indicating maximum noise reduction.

• The Average function can be turned off by pressing Free Run. This will erase the fiber signature that was previously stored.

17) Hi Res (High resolution): The Hi Res button increases the distance resolution of the fiber signature by approximately a factor of four. This is accompanied by a reduction in signal-to-noise ratio.

• Pressing Hi Res while the Model 3100H is in free run mode switches the OTDR to the high-resolution mode. Pressing Hi Res a second time turns the high resolution mode off.

• Pressing Hi Res while the 3100H is in average mode switches the OTDR to the high resolution mode, and also preserves the previously stored (normal resolution) fiber signature. Pressing Hi Res a second time returns the previous signature to the display.

• When Hi Res is used, all pulses decrease in width from 250m (820 ft) to 50 m (164 ft) (125m and 25m in multimode).

• When Hi Res is used, a 12.5 km (41 kft) segment of the fiber signature can be averaged and stored at one time.

• If the distance scale is set above 1 km (3.3 kft/division) before Hi Res is turned on, then pressing Hi Res will automatically reduce the distance scale to 1 km/division. Refer back to item 10, Distance Scale.

4. THE 3100H DISPLAY

4.0 Refer to Figure 2-3, Typical Display, while reading the following descriptions.

• Display Window Indicator: The display window indicator shows the size and position of the display window in relation to the entire distance range of the Model 3100H. (The display window is the span of distance and loss shown on the display at any given time.) The distance scale knob and the center distance knob affect the position of the display window.

• Numerical Readout: Three different kinds of data may appear at this position, depending on the measurement being performed.

a. Delta -- The relative distance, and loss from vertical line reference marker to the "+" marker (total and per kilometer or kilofeet), are indicated.

b. Splice Loss – The results of auto or manual splice loss measurements are indicated. The three numbers shown are the splice distance, splice loss, and confidence limits.

c. All other modes -- marker distance is indicated in km or feet, as determined by the km/feet switch on the rear panel (refer to Figure 2-4, Rear Panel). The indicated distance is absolute, from the optical connector of the Model 3100H to the "+" marker.

• Plug-in Indicator: The model number of the plug-in is indicated when the following plug-ins are installed: 313L, 313M or 628H (in switchable mode).

• Averaging Status: This field displays a count of 1 to 256 during the averaging (noise reduction) process. A full average has taken place when "256" is displayed. For a complete discussion, refer to item 16, discussed under Figure 2-2, Front Panel.

• Vertical Scale Readout: The current setting of the dB scale control is indicated, in dB per division.

• Horizontal Scale Readout: The current setting of the distance scale control is indicated, in km or m per division.

• Refractive Index: The current setting of the refractive index is indicated.

• Wavelength Indicator: The current wavelength is displayed. Pressing the Local button updates the wavelength display after the 628H plug-in switch is changed.

• Marker ("+"): The "+" symbol is the marker, which is used to perform distance and loss measurements. The delta and splice loss functions produce additional vertical line markers, as described in Section 3, Operation.

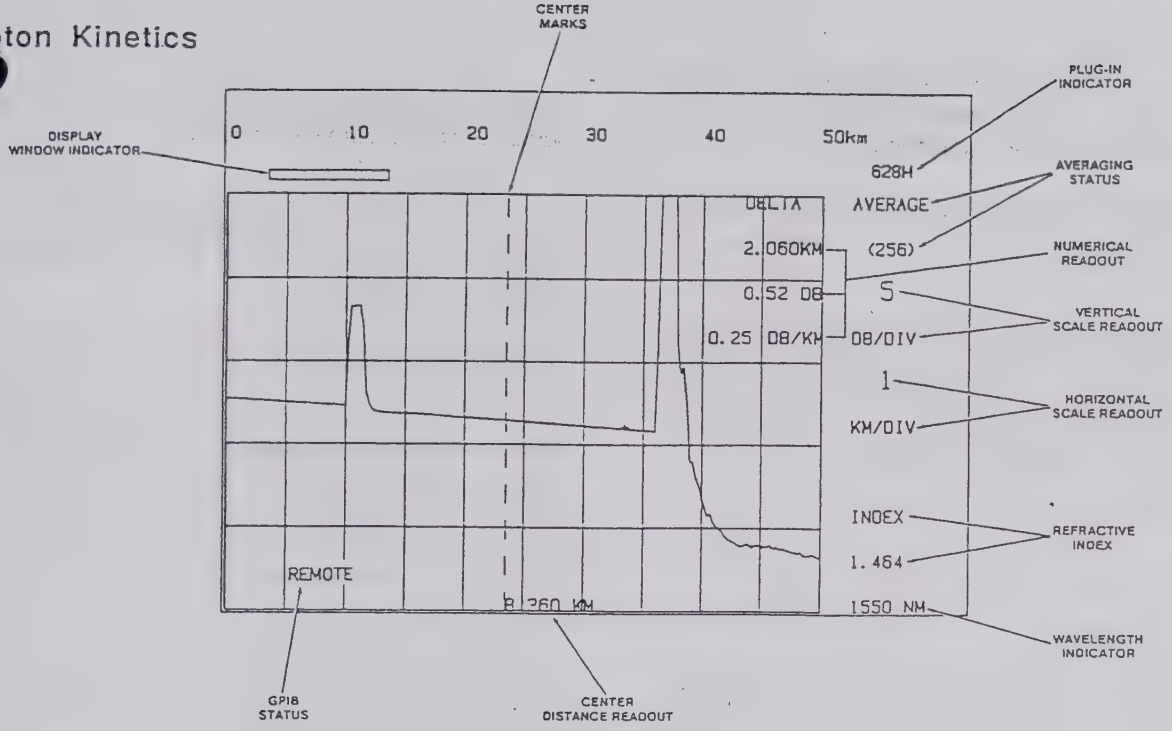


Figure 2-3. Typical Display.

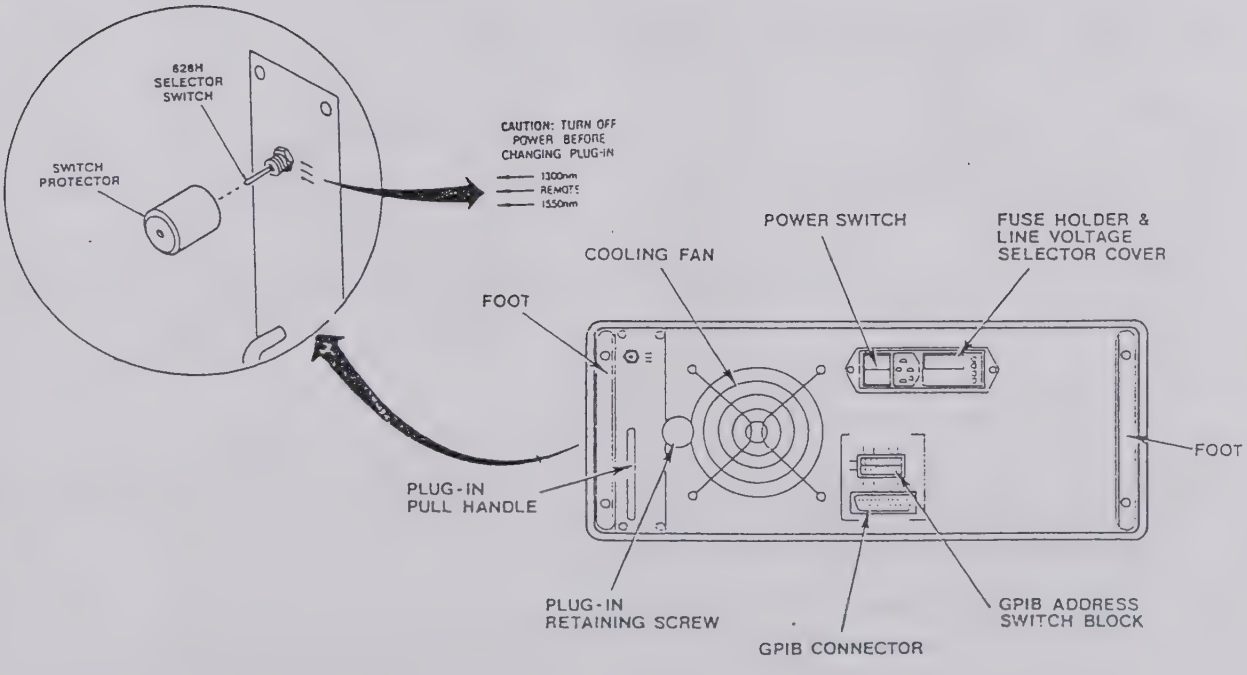


Figure 2-4. Rear Panel.

• Center Marks : These marks denote the center of the display window. Distance scale changes expand the display window around this center line.

• Center Distance Readout: The distance from the Model 3100H optical connector to the center of the display window is indicated.

• GPIB Status: When the Model 3100H is under remote control by way of the GPIB interface, "REMOTE" appears. When the Local button is pressed, the GPIB address setting of the Model 3100H is momentarily displayed in this position.

5. REAR PANEL

5.01 Refer to Figure 2-4 while reviewing the items on the rear panel.

• Power Switch: This switch turns the OTDR on and off. Toggling this switch too rapidly (within 30 seconds) can damage the machine. The power cord connector is directly to the right of the power switch.

• Fuse Holder/Voltage Selector Cover : The voltage selector controls the variable voltage and is the socket for the fuse. See "Changing the Fuse" in Section 3, Operation, for instructions.

• Fan: This fan is always on during operation, to prevent overheating.

• GPIB Connector. This 24-pin connector allows an optional plotter or GPIB devices to be connected to the OTDR.

• GPIB Address Switch Block: The first five dip switches on the left can be toggled on or off, setting the address for the GPIB. The sixth switch sets the active terminator to line feed (LF) or end of file (EOF). The seventh dip switch sets the default splice loss measurement mode to automatic or manual and the eighth switch sets the measurement to meters or feet. If this switch is changed while the OTDR is operating, the OTDR must be turned off then turned on to implement this change. See Section 4, GPIB, for illustrations and detailed information.

• Plug-in Retaining Screw: This screw locks the plug-in module securely in the OTDR.

• Plug-in Pull Handle : This handle protrudes from the opening for the 1300 or 1550nm plug-in module. Insertion instructions for the plug-in are given in Section 3, Operation.

• Wavelength Selector Switch (628H plug-in only): This switch selects the wavelength of the dual-wavelength plug-in (628H). The top position is 1300nm, the bottom position is 1550nm, and the middle position allows the front panel Wavelength button to control the wavelength setting. The Local button must be pressed to update the display after this selector switch has been changed.

• Lock for Selector Switch: This screw-on cap locks the wavelength selection in selectable mode (middle position) so the wavelength can be controlled from the front panel. To remove it, unscrew the cap.

• Feet : These pads let the OTDR rest firmly when upright.

SECTION 3: OPERATION

1. OVERVIEW

1.01 This section describes how to use the Model 3100H, and how to obtain accurate measurements. The material in this section is presented in several parts:

- Connecting fibers and startup procedure.
- Primary operating modes of the Model 3100H, and how to obtain a display of a fiber signature. This material will be useful to the first-time user who is getting started with the Model 3100H.
- How to obtain accurate distance and loss measurements with the Model 3100H, in various measurement situations. This part also describes some of the special operating modes of the Model 3100H.
- Miscellaneous procedures, including changing fuses, installing plug-ins and plotter output.

2. CONNECTING FIBERS TO THE MODEL 3100H

2.01 Proper performance of the Model 3100H depends on the quality and condition of the front panel optical connector. Particles of dust or dirt will cause poor connector performance and can damage the connector. The use of proper handling and cleaning procedures each time the connector is used is essential.

Dust Caps

2.02 All plugs and sleeves are shipped with dust caps. These caps should not be removed until immediately prior to use and should be replaced immediately after use.

Sleeve Cleaning

2.03 Wipe the inside of the sleeve with a foam swab soaked in alcohol (electronics grade isopropyl). With light pressure, twist the end of the swab against the inside plug sleeve. Immediately blow dry with clean compressed air. Be sure of propellant expelled from canned air; it can degrade performance.

Plug Cleaning

2.04 Wipe the plug tip and ferrule with a lint-free tissue moistened with alcohol (electronics grade isopropyl), using a twisting motion. Immediately blow the plug dry with clean compressed air.

For SMA and biconical connectors:

1. Clean the sleeve and the plug immediately prior to mating. Inspect the plug carefully. If dust or lint particles are visible, clean it again.

2. With one hand, hold the plug by the strain relief so that the plug tip cannot rotate. Screw the plug retainer directly into the sleeve with the other hand, until it is just finger-tight. Never push the plug tip forward or allow it to rotate.

3. To unplug the connector, hold the strain relief with one hand. Do not allow plug rotation while the plug retainer is unscrewed.

4. If the fiber signature on the Model 3100H indicates that the quality of the connection is below normal, unplug the connector completely, rotate the plug 90 degrees, and re-mate the connector. Do not rotate the plug while it is mated. Refer to "Verifying the Fiber Connection".

For ST, Diamond, FC and D4 connectors:

1. Clean the sleeve and the plug immediately prior to mating. Inspect the plug carefully. If dust or lint particles are visible, clean it again.

2. Carefully insert the plug into the sleeve, aligning the plug key with the slot in the sleeve. Push the plug into the sleeve only as far as it will go easily.

3. For ST: twist plug until it locks.

4. For the others: screw on the plug retainer until it is just finger tight.

WARNING: Fiber connectors are extremely sensitive to contamination and rough handling.

2.05 It cannot be overemphasized how important it is to use the front panel optical connector properly. Improper connection will result in poor instrument performance. Improper care during connection can result in immediate damage to the connector, which can only be remedied by connector replacement. Connector replacement is expensive, time consuming, and requires special tools.

2.06 An Optical Connector Usage Guide is supplied with every plug-in from Photon Kinetics. The usage guide is specifically written for the type of connector on the plug-in. The connection procedures given in this guide should be followed exactly every time an optical connection is made.

Using a Pigtail Cable

2.07 The optional pigtail cable enables use of any connector or fiber splicing method. Not only does this accommodate any connection situation, it also means fewer front panel connections. The risk of front panel connector damage during connection is greatly reduced because the instrument connection can be left undisturbed. Always follow the procedures in the Optical Connector Usage Guide when connecting the pigtail to the Model 3100H.

Using a Long Pigtail

2.08 When measuring splices or other features near the beginning of a fiber, it may be helpful to connect a 1 km spool of fiber between the Model 3100H and the fiber under test. This insures that the initial pulse does not obscure close-in features.

2.09 In order to provide this advantage, the long pigtail must be spliced in such a way that there is little or no pulse reflection. A fusion splice, or a connector that provides glass-to-glass contact, will accomplish this. Special jumpers for any configuration are available. See the options discussed in Section 2, Description.

3. STARTUP PROCEDURE

3.01 The Model 3100H is easy to start up, but the simple procedures should be followed carefully.

Power Requirements

3.02 The Model 3100H operates on 50/60 Hz single-phase power with protective ground. The single-phase power source should have one of its current-carrying conductors at ground (earth) potential. Avoid power sources where both current-carrying conductors are isolated or above ground potential such as phase-to-phase on a multi-phase system or across the legs of a 110-220 volt single-phase, three-wire system.

DANGER: Do not defeat the protective ground by either cutting it, or bypassing it with an improperly terminated adaptor.

3.03 The line voltage range can be switched from 105-125 VAC to 210-264 VAC. Refer to Changing the Line Voltage later in this section.

WARNING: Serious damage to the instrument can result if the input voltage applied does not match the operating voltage range selected.

Power-up Procedure

1. Open or remove the instrument cover and position the carrying handle as desired. To move the handle, simultaneously press in and hold the black buttons on the left and right handle pivots. Swing the handle to the approximate position desired, then release the buttons. Swing the handle slightly until it locks into place.

2. Check that the Model 3100H is set for the AC line voltage available, and that the AC power source is properly wired and grounded. Also verify that the optical plug-in is correctly installed. Refer to the end of this section, if necessary.

3. The power switch is located on the rear panel. Move the switch from "0" to "1" (OFF to ON). All front panel button LEDs should light for about one second, after which only the Free Run button LED should remain lit. A display should appear after a brief warm-up period of 10 to 20 seconds. (The Intensity control may have to be turned clockwise.) When the Model 3100H is first turned on, Free Run is automatically selected. If a 628H plug-in is installed and the rear panel switch is in the middle position, the default wavelength is whichever was selected last.

3.04 If the Model 3100H does not come on, check the AC power source, the power connection both at the instrument and the AC outlet, the line voltage setting, and the fuse. Refer to the end of this section if necessary.

WARNING: Do not rapidly toggle the power switch from "on" to "off" to "on". Wait at least 30 seconds before turning the instrument back on. Otherwise, damage to the power switch may result.

4. LEARNING TO USE THE MODEL 3100H

4.01 The following explanations of the basic operations of the Model 3100H will acquaint the new user with the primary controls and operating procedures of the instrument. It will be helpful (but not necessary) to have a fiber connected to the instrument while learning the basic operations. If a fiber at least 1 km (3.3 kft) long is available, connect it using the instructions listed under Connecting Fibers to the Model 3100H.

The Display Window

4.02 The Model 3100H display can show the entire signature of a fiber, up to 40 km (131.2 kft) or a magnified section of the signature. The display window is the span of distance (horizontal) and optical loss (vertical) shown on the display at any given time. The display window setting at power-on begins at the near end of the fiber ("zero distance"), and extends to 40 km (131.2 kft).

4.03 The window can be moved to view any portion of a fiber signature. For example, the display window can begin at the 10 km (33 kft) point and end at 12 km (39.4 kft).

4.04 The display window indicator is a bar that appears across the top of the Model 3100H display. This bar shows the position and size of the display window (refer to Figure 3-1, The Display Window and Display Window Indicator). The display window indicator is an aid in visualizing where the display window is located.

4.05 Use the Distance Scale knob (outer ring) to set the width of the display window (i.e., what length of fiber will be seen on the display at one time). The display window width can be varied from a maximum of 40 km or 4 km/division (131.2 kft or 13.1 kft/division) to a minimum of 2 km or 200 m/division (6.6 kft or 660 ft/division). In the special Hi Res function, the display window can be narrowed to 100 m or 50 m/division (.164kft or 164.0 ft/division).

4.06 Refer to Figure 3-2 while changing the display window.

The wavelength indicator on the bottom right must be updated after the rear-panel switch of the 628H plug-in is moved to a new position. It will change automatically when the Wavelength button is used. For all other plug-ins, the wavelength display will not change.

4.07 Watch the display window indicator and numerical readout on the upper right portion of the display as you change the distance scale.

4.08 Use the Center Distance knob (11) to move the display window "left" or "right" along the fiber. The display window indicator at the top of the screen shows the effect of this motion.

4.09 The distance from the Model 3100H fiber connector to the center of the display window is indicated by the center distance readout at the bottom of the screen.

The Vertical Scale and Position

4.10 The display window is moved and magnified vertically by the dB Scale (8) and Vertical Position (9) controls.

4.11 Use the dB Scale knob (8) to set the display's vertical dB/division loss scale (vertical magnification). The smaller the number, the higher the magnification factor. The available ranges are 5, 1, and 0.5 dB/division of one-way fiber loss. A numerical readout on the upper right portion of the display shows the present dB scale.

4.12 Use the Vertical Position knob (9) to move the display window up and down on the fiber signature.

The Marker

4.13 The Marker control (12) moves a location marker ("+" on the display) along the fiber signature. In the upper right corner of the display, a digital readout indicates the distance from the connector to the marker, in kilometers or feet. (km/feet operation is selected by a switch on the rear panel. Refer to Figure 4-2 in Section 4, GPIB Interface.)

4.14 The Marker control is also used for measuring the loss and distance between two points on a fiber, and for measuring splice losses. These uses of the Marker control are discussed later in this section under Measurement Procedures.

5. AVERAGING

5.01 The Model 3100H can display a fiber signature in one of two ways: "Free Run" or "Avg" (averaged). Averaging is the process by which the Model 3100H stores a fiber signature with reduced noise. Most measurements made on an averaged signature are more precise than those made while the instrument is in free run mode. For an example of how averaging can improve the display, refer to Figure 3-3.

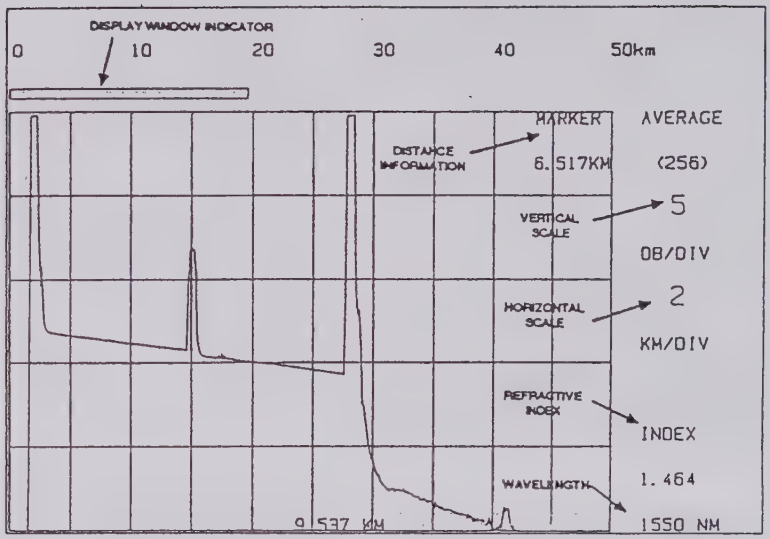


Figure 3-1. Display Window and Indicator.

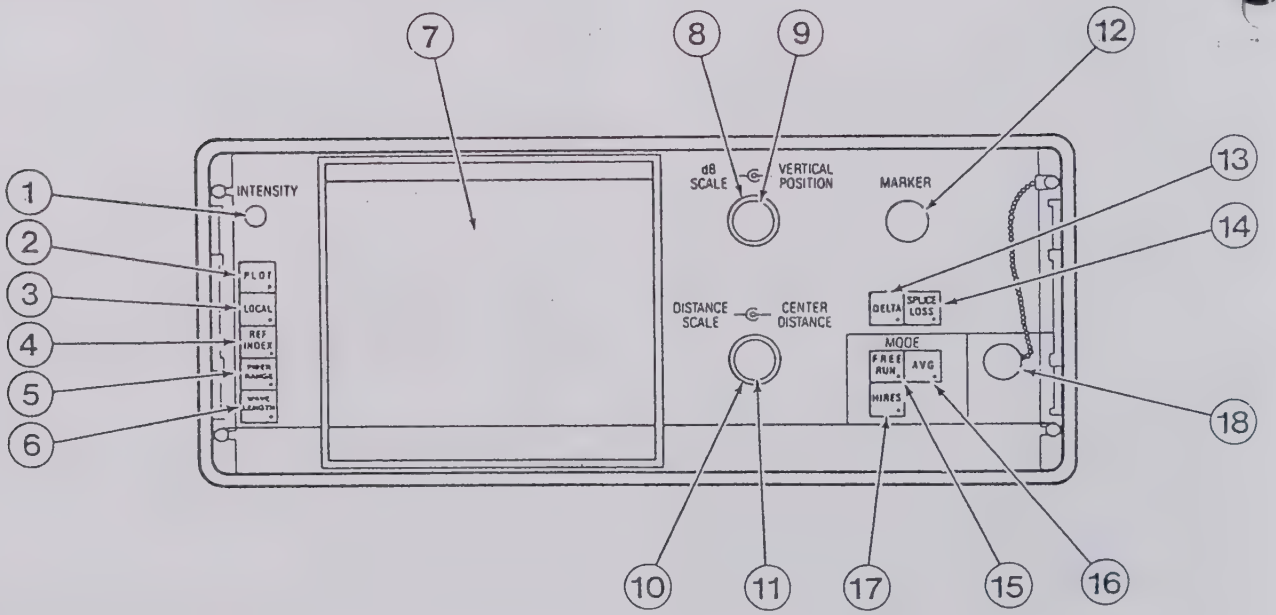
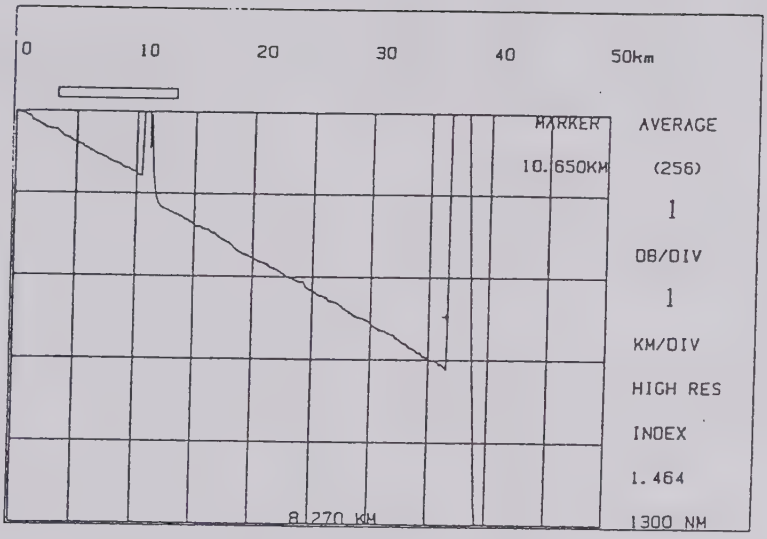
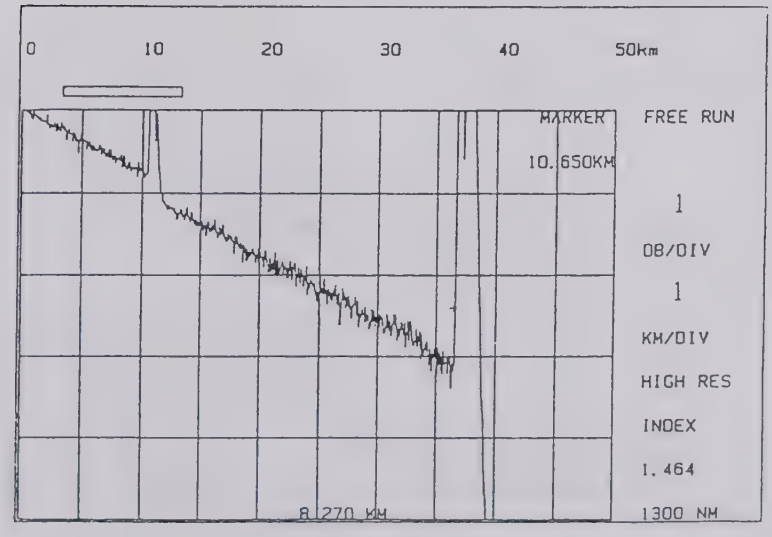


Figure 3-2. Front Panel.



A. Averaged



B. Free Run

Figure 3-3. Averaged and Free Run Compared.

5.02 The averaging process is started by pressing Avg. Full averaging (maximum noise reduction) takes approximately 60 seconds. A numerical readout at the right side of the display shows the progress of the averaging operation, by counting from 1 to 256. If complete noise reduction is not needed, pressing Avg a second time stops the averaging process any time before the full 60 seconds is over.

5.03 During averaging, the marker can still be moved, and the display window can still be moved or expanded as desired. This feature saves time and allows the most efficient use of the Model 3100H.

5.04 When the Model 3100H is being used in its most common operating configuration (50 km (164 kft) distance range and Hi Res off), it does not matter how the display window is set before averaging starts. The Model 3100H averages and stores the entire fiber signature, from 0 to 50 km (164 kft), including portions that are outside the display window.

5.05 The Model 3100H has two special operating configurations in which it does matter where the display window is set before averaging is started, because the stored signature will not include everything that falls outside the display window. These special configurations are the 100 km (328.1 kft) distance range and Hi Res, which are described later in this section under Measurement Procedures.

5.06 After making all desired measurements, return to the free run mode by pressing the Free Run button. Averaging can be canceled at any time by pressing Free Run. Once Free Run is pressed, the stored signature is lost.

6. VERIFYING THE FIBER CONNECTION

6.01 Once a fiber connection has been made and the Model 3100H is running, a signature similar to that shown in the top portion of Figure 3-4 should be seen. The height of the fiber signature above the noise indicates the quality of the optical connection. Some connectors and quick splices can be adjusted to improve the connection.

6.02 Note that the "+" marker is always on screen, regardless of the signature position. If the signature is off the bottom of the display, the marker "+" will be somewhere along the bottom of the screen. If the signature is off the top of the display, the marker will be somewhere along the top.

6.03 To verify the fiber connection, do the following:

1. Be sure the Model 3100H is in free run mode. (Press Free Run.)

2. Set the display window to view the fiber signature at 4 km/div.

3. Set the dB scale to 5 dB/division, and adjust the vertical position control so that the bottom of the noise lies exactly at the bottom of the display window. See Figure 3-5.

4. The backscatter signal at the start of the fiber signature should be at the top of the display (approximately three and one half divisions above the noise). This can vary with different types of fiber and with normal variations in connector loss. (Terminology related to fiber signatures is explained below under Fiber Signatures.) If the initial backscatter signal is substantially lower than normal, the fiber connection is probably not good.

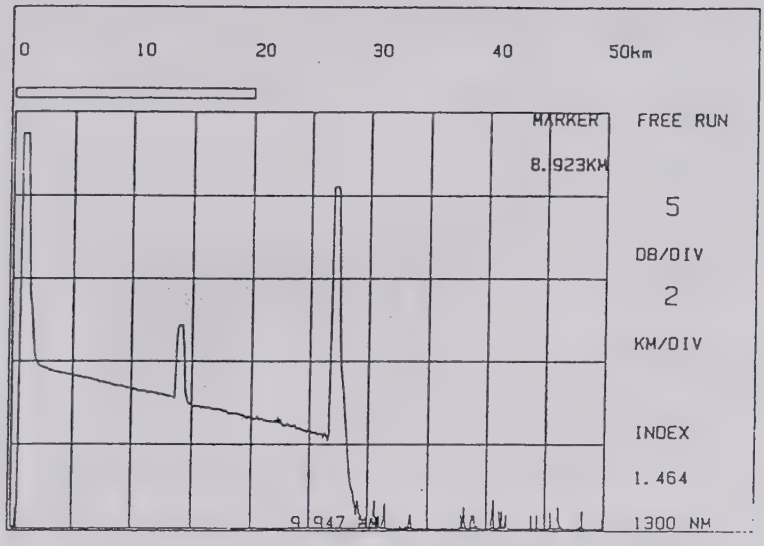
6.04 The effect of remating or adjusting the fiber connection can be observed "real time" while the Model 3100H is in free run mode. If by adjusting the connection the amplitude can be increased, long distance measurements will improve.

WARNING: Use extreme care when adjusting single-mode connectors. Some are especially sensitive to damage when loosely mated.

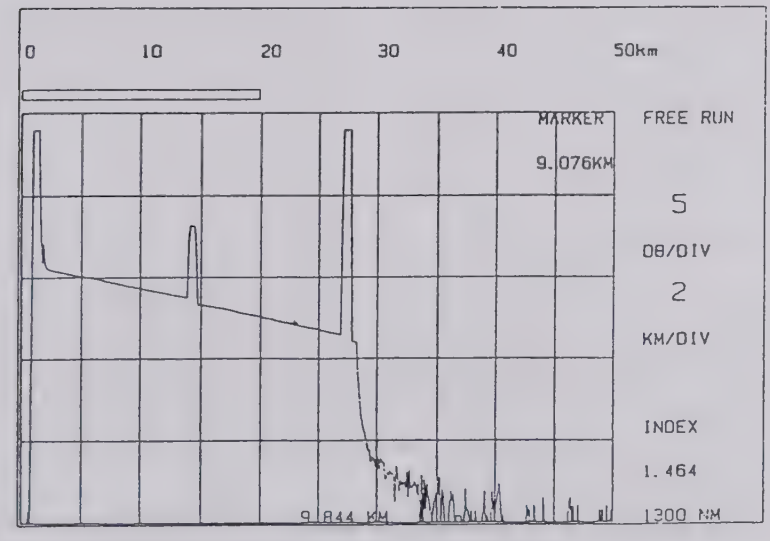
6.05 Be sure to follow the preparation and connection procedures given in the Optical Connector Usage Guide provided with the instrument.

7. FIBER SIGNATURES

7.01 Figure 3-6 shows a typical fiber signature and its components. This figure and the items described below illustrate many of the signature features encountered during measurements.



Poor



Good

Figure 3-4. Fiber Connections.

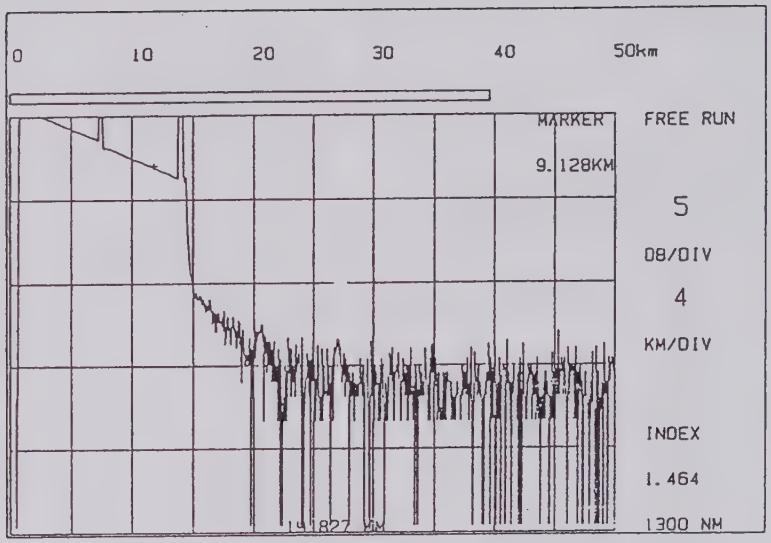


Figure 3-5. Vertical Position of Signature.

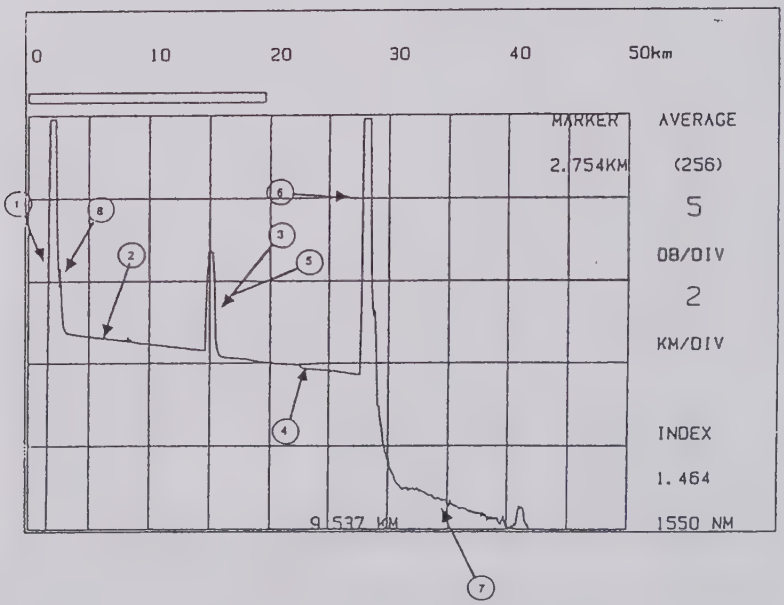


Figure 3-6. Typical Fiber Signature.

1) Initial Pulse: This is the initial reflection due to the front panel connector. This pulse will look the same in every fiber signature. Useful measurement information begins only after this pulse.

2) Backscatter Signal: This section of the signature shows the continuous backscatter from the fiber. The downward slope indicates attenuation in the fiber.

3) Pulse Reflection: Any pulse that appears in the fiber signature, past the initial pulse, is called a pulse reflection. Pulse reflections are caused by any evenly-cut fiber end, including those inside some types of connectors and splices. Two kinds of pulse reflections are reflective splices and end reflections. Both are explained below. The height of a pulse reflection is generally not of concern.

4) Non-Reflective Splice: The abrupt drop in the backscatter signal is caused by the loss in a non-reflective splice. (A similar drop in the backscatter signal can occur at the location of a cable fault.) Fusion splices are the most common non-reflective splices.

5) Reflective Splice: A reflective splice shows up in the fiber signature as the combination of a pulse reflection and a drop-off in the backscatter signal. Most mechanical splices are often reflective. Reflective splices are generally easier to find in the fiber signature than non-reflective splices, but more difficult to measure for splice loss (the pulse reflection obscures part of the backscatter signal).

6) End Reflection: If a pulse reflection appears at the end of a fiber, it is termed the end reflection. The end reflection is identified by the fact that there is no further backscattering signal after this pulse. Note that a fiber without a clean, flat end may not show an end reflection.

7) Noise Floor: The noise floor is the sensitivity limit of the Model 3100H. As the fiber signature approaches the noise floor, precise loss measurements become difficult. The noise floor is lowered by the averaging process.

8) Pulse Recovery : At the end of the initial pulse and any reflected pulse, a pulse recovery occurs before the Model 3100H shows the continuation of the backscatter signal. It may vary in shape from that shown in Figure 3-6. The pulse recovery portion of the signature does not give any useful measurement information. The Model 3100H is designed for the fastest possible pulse recovery.

8. MEASUREMENT PROCEDURES

8.01 The following material describes how to make accurate measurements with the Model 3100H. The new user should first review the previous description of basic operations to gain an understanding of how to use the primary Model 3100H controls.

8.02 The procedures below assume that the user has already connected a fiber to the Model 3100H, used the average function to store the fiber signature and learned how to position the display window to examine signature features of interest.

8.03 Plug-ins are available for 1300 nm and 1550 nm measurements, either single plug-ins or a dual wavelength plug-in. Because cable and splice losses can be highly wavelength-dependent, fiber installations should be verified at each wavelength for which operation is ultimately anticipated. Because of the lower attenuation of single-mode fiber at 1550 nm, the Model 3100H can usually locate faults significantly farther down a fiber at this wavelength. The plug-ins are listed in Section 1.

9. DISTANCE MEASUREMENTS

9.01 Distance can be measured either absolutely (from OTDR to feature) or relatively (from one feature to another). Generally, the most accurate distance measurements are made in the HI RES mode, on a fully averaged fiber.

Setting the Refractive Index

9.02 Accurate distance measurements require that the refractive index be correctly set. A measurement taken at the wrong index will be off by the ratio of actual to measured indices.

9.03 Example: A distance measurement to a splice which is actually 6 miles from the OTDR is taken with the reference index incorrectly set to 1.499. If the actual reference index is 1.460, the operator will read:

$$6\text{mi}\left(\frac{1.460}{1.499}\right) = 5.844 \text{ miles, an error of } 823.68 \text{ feet}$$

9.04 To set the refractive index, do the following:

1. Press Ref Ind.

2. Turn the Marker control while noting the refractive index readout in the right hand portion of the display.

3. Once the value is correct, press Ref Ind again to lock in the refractive index and restore normal marker operation.

The refractive index of telecommunication fibers is usually near 1.46.

Determining the Refractive Index

9.05 If the refractive index is not known but the exact distance to a point along the fiber is known, do the following:

1. Position the marker to the known point on the fiber signature.

2. Press Ref Ind.

3. Adjust the Marker control until the distance readout matches the known distance. The greater the distance to the known point, the more accurate the refractive index setting will be.

4. Press Ref Ind again to lock in the refractive index and restore normal marker operation.

Marker Positioning

9.06 To accurately locate a pulse reflection with a marker, position the marker at approximately 1.5 dB below the peak of the signature on the leading edge of the reflection, as indicated in Figure 3-7.

9.07 To accurately locate a non-reflective splice, position the marker at the start of the fall-off in the backscatter signal as shown in Figure 3-8.

Measuring Absolute Distance

9.08 To measure the distance from the Model 3100H to any point on the fiber, do the following:

1. Using the Marker control, place the "+" marker at the desired point. Position the display window to magnify the point of interest, for maximum accuracy.

2. Read the distance value from the upper right portion of the display. This readout shows the absolute fiber distance from the OTDR, including any pigtail cable.

3. To measure distance to a splice or other anomaly, set the marker within 50 meters of the point, and push the Splice Loss button (in auto splice mode).

9.09 The distance readout can be displayed in either kilometers or feet. A switch on the rear panel changes the selection. This switch is shown in Figure 4-2, Switch Block, in Section 4, GPIB.

Measuring Relative Distance

9.10 The relative distance between any two features is determined in the delta measurement mode, as follows:

1. Using the Marker control, position the "+" marker at the starting point of interest.

2. Press Delta. A straight line through the [illegible] appears coincident with the "+" marker and is locked in as a reference.

3. Use the Marker control to move the "+" marker to the second feature. The vertical line remains fixed. The delta readout at the upper right portion of the display shows the distance between the two markers, difference in dB and difference in dB per kilometer. The reference marker does not have to remain in the display window. The display window can be expanded and moved while going from one feature to the other.

4. Press Delta to end the delta operation.

10. LOSS MEASUREMENTS

10.01 The loss between any two points along a fiber where the backscatter signal is visible can be measured by the drop in the fiber signature. Set the "+" marker on the first point and press Delta to lock it in. Then move the "+" marker to the second point and note the dB loss readouts on the right side of the display. The reference marker d[illegible] not have to remain in the display window.

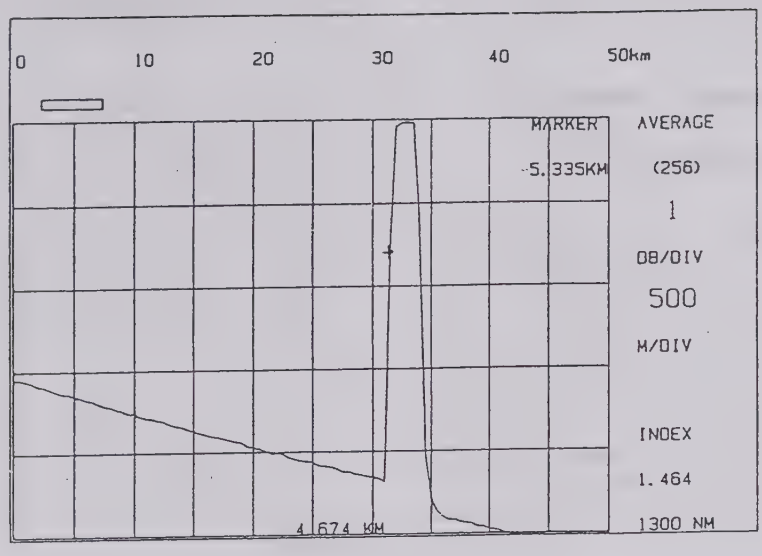


Figure 3-7. Marker Position, Reflective Feature.

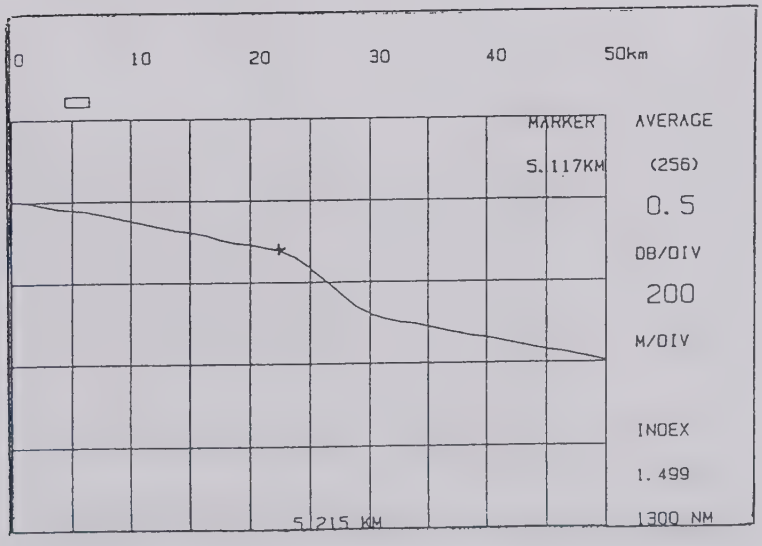


Figure 3-8. Marker Position, Non-reflective Feature.

10.02 Alternatively, the system loss from the start of the fiber to the end can be determined as in signature B of Figure 3-9.

10.03 End the delta measurement by pressing Delta .

11. SPLICE LOSS MEASUREMENTS

11.01 The Model 3100H has two means of performing splice loss measurements. For maximum convenience, quickest results and repeatability, these measurements will normally be performed in the auto splice loss mode. Manual mode will be required if the splice being measured is within approximately 1 km of a second splice. To switch from manual to auto mode and back, hold the Splice Loss button in. The instrument will toggle between the two modes indicated in the upper right hand corner of the display. Release the button and press it quickly again to implement the selected mode.

11.02 It is important that the splice signature be properly located and expanded on the display as described below. Once the measurement begins, the vertical and horizontal controls are inactive.

11.03 In either the auto or manual procedure, the Model 3100H calculates and reads out the splice location, loss, and 90% confidence limits. The confidence limits indicate the uncertainty of the measurement (as determined by the amount of noise, and how well the Model 3100H is able to fit straight lines to the fiber signature). Confidence limits represent the range of results which would be obtained in 90% of statistically identical measurements.

11.04 Splice loss measurements are best made with full averaging, in normal (not Hi Res) mode.

Auto Splice Loss

11.05 Use the following procedure to measure both reflective and non-reflective splices:

1. Be sure the auto/manual splice loss mode is in the auto position.

2. Position the display window to locate and expand the splice signature of interest. Because the auto splice loss measurement utilizes only the portion of the signature that is contained in the display window, it is important to use the proper display scales. Refer to Figure 3-10 while adjusting the horizontal and vertical positions of the splice signature.

   a. Horizontal: Move the display window so that the splice to be measured is near the center of the display (within one division). Increase the distance scale so that the entire linear portion of the backscatter signal on both sides of the splice (up to the next splice or discontinuity in both directions) is contained in the display window. It does not matter if another splice or discontinuity appears in the display window.

   b. Vertical: Decrease the dB/division scale so that the signature is magnified, but not so much that the linear portion of the backscatter signal on either side of the splice is cut off at the top or bottom of the display.

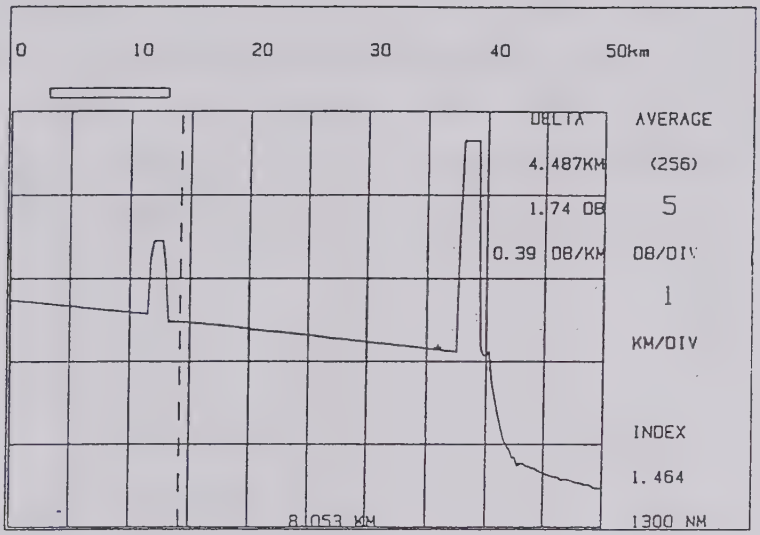
3. Set the marker close to the splice (refer to Figure 3-10). The marker must be within one pulse width (approximately 250 meters (820.2 ft) in normal resolution) of the splice in order to make a good measurement. With 500m/division (1640.4 ft/division) magnification, this would be half of a division on the screen.

4. Press Splice Loss. The Model 3100H locks onto the splice and indicates this by a vertical line through its center. The instrument then fits straight lines to the backscatter signal for the greatest possible distance on both sides of the splice. The splice loss, distance, and confidence limits are shown in the display readout. Figure 3-11 shows examples of the resulting display for reflective and non-reflective splices.

5. Press any control except Marker to end the splice loss measurements.

11.06 If an error message appears on the display after Splice Loss is pressed, check to see that the splice is near the center of the display window. Also check that the marker is located properly on the splice and that a straight section of the backscatter signal appears on both sides of the splice.

11.07 To abort the splice loss measurement at any time, press Local.



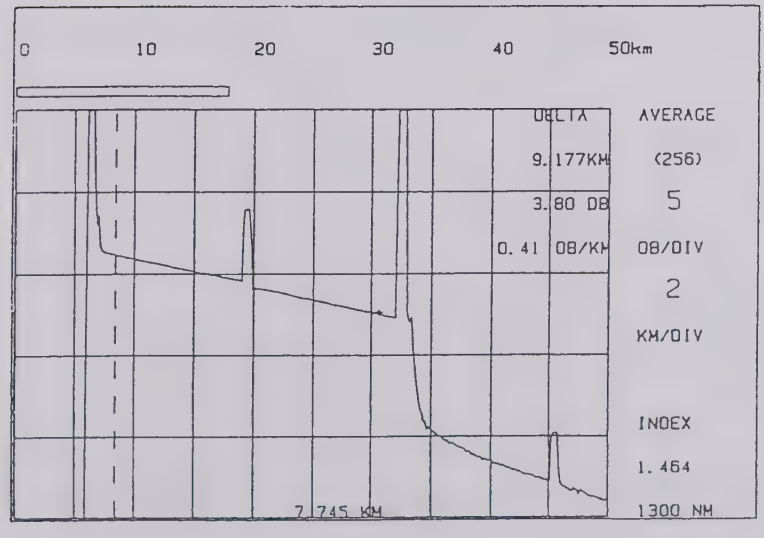
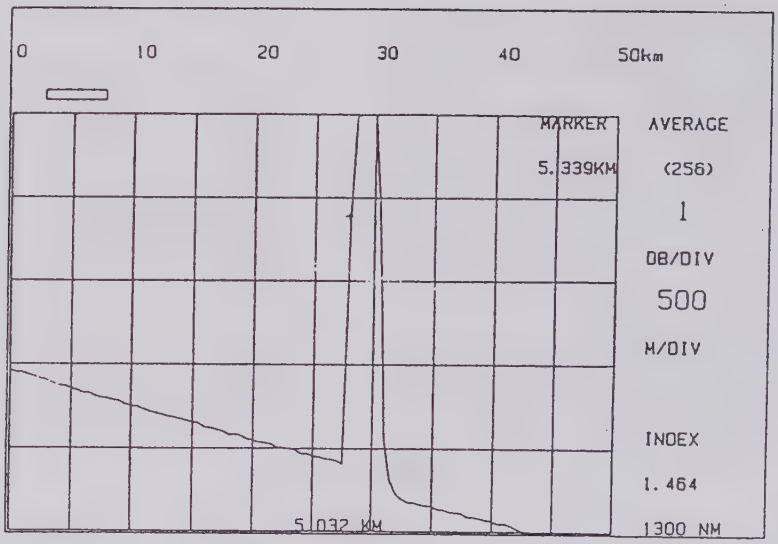
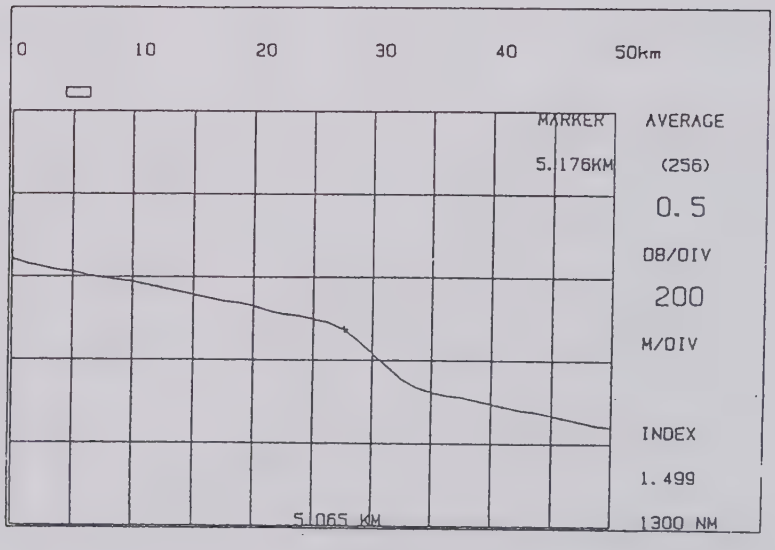


Figure 3-9. Fiber Attenuation.

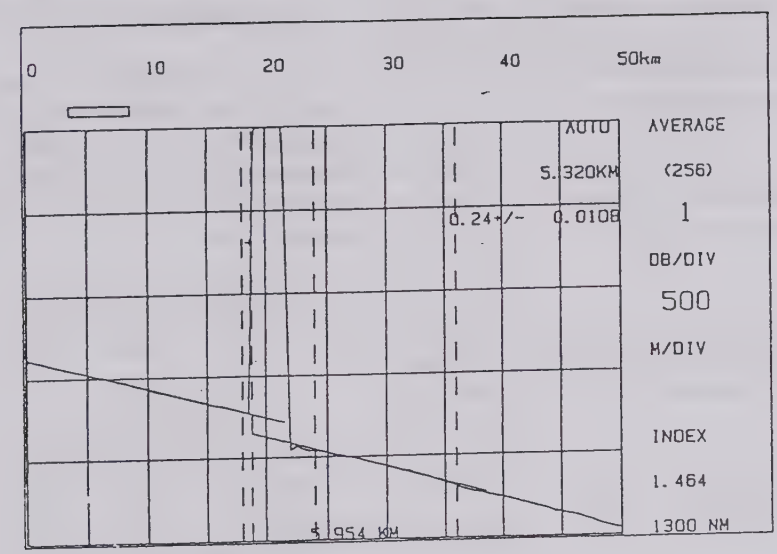


A. Reflective Splice

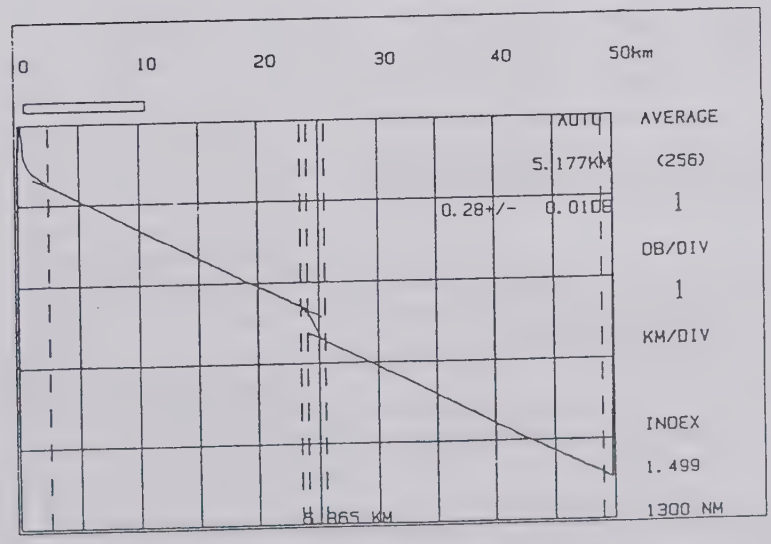


B. Non-reflective Splice

Figure 3-10. Proper Positioning of Marker.



A. Reflective Splice



B. Non-reflective Splice

Figure 3-11. Auto Splice Loss Measurement.

11.08 If the signature at or near the splice is otherwise unsuitable for the automated splice loss determination, the procedure will abort before completion, as indicated by the lack of a lock-on or straight line fit. Such a situation may result from having another splice or discontinuity too close to the splice of interest. In this case (or if the confidence limits are more than a small fraction of the dB loss itself) the manual procedure should be performed.

11.09 One way to ensure that two closely-adjacent discontinuities will not be measured together is to position the display window to exclude one discontinuity.

Manual Splice Loss

11.10 Use the following procedure if the fiber signature is unsuitable for automatic splice measurement as described above.

1. Hold in the Splice Loss button until the Model 3100H is in manual mode.

2. With the fiber signature averaged, locate and expand the splice signature as described above for the auto measurement.

3. Set the marker at the precise location of the splice.

4. Press Splice Loss. The Model 3100H places five vertical line markers. These markers can be placed in any order as they are unlocked one by one. One suggested procedure for positioning markers is listed below.

a) Turn the Marker control to reposition the center marker to the location of the splice (this is different for reflective and non-reflective, see Figure 3-10).

b) Press Splice Loss. The center marker locks into place, and the first marker on the left becomes movable.

c) Turn the Marker control to reposition the left marker as far left as possible without encompassing another discontinuity.

d) Press Splice Loss again. The left marker locks into place, and the second marker becomes movable. Move this to the beginning of the splice.

e) Reposition the remaining markers in sequence using the Marker control and the Splice Loss button as noted in steps 3 and 4. Marker 3 should be at the end of the splice and marker 4 should be as far right as possible without encompassing another feature.

11.11 As soon as the fifth marker is locked in place, the straight lines reappear, joining the markers. The splice measurement results appear in the readout, with the distance in feet or kilometers on the top right, the loss on the left below that, and the confidence limit to the right, as shown in Figure 3-12.

11.12 To cancel the splice loss measurement at any time, press Local.

12. MEASUREMENTS ON VERY LONG FIBERS

12.01 If a fiber longer than 50 km (164 kft) is to be tested, the Model 3100H should be set to the 100 km (328.1 kft) distance range (Fiber Range button). Otherwise, "ghost" pulses may appear near the beginning of the fiber signature, which are actually reflections from distant points on the fiber. In the 100 km distance range, the display window indicator changes as shown in Figure 3-13.

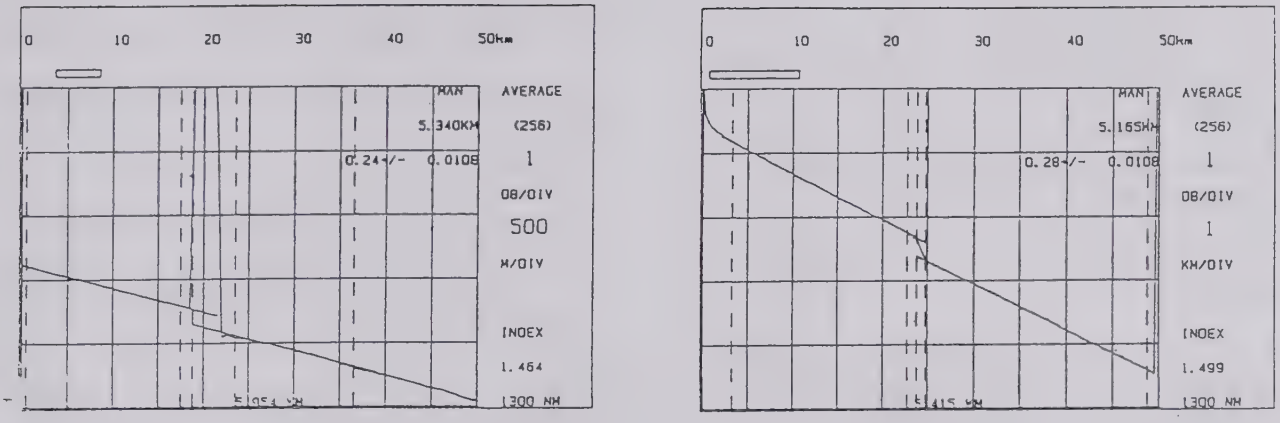
12. 02 When using the 100 km distance range, two changes occur in the averaging function:

1. The time required to obtain a given degree of noise reduction is doubled.

2. When a fiber signature is stored, 50 km (164 kft) of the signature is held by the instrument at one time. When the Avg button is pressed, the 50 km (164 kft) segment beginning at the left edge of the display window is averaged and stored. After averaging, display window movements are limited to within the stored section. The 100km range can be changed to 50 km (164 kft) only in free run mode.

13. HIGH RESOLUTION MEASUREMENTS

13.01 The normal pulse length of the Model 3100H on single-mode fiber is 250m. It is 125m for the multimode plug-in. If closely spaced details in a fiber signature require extra resolution, the Hi Res function provides 50m pulses for single-mode and 25m pulses for multimode. Hi Res can be used with either the 50 km (164 kft) or 100 km (328 kft) range limits. The higher distance resolution of Hi Res is accompanied by slightly less backscatter range.



A. Reflective Splice

B. Non-reflective Splice

Figure 3-12. Manual Splice Loss Measurement.

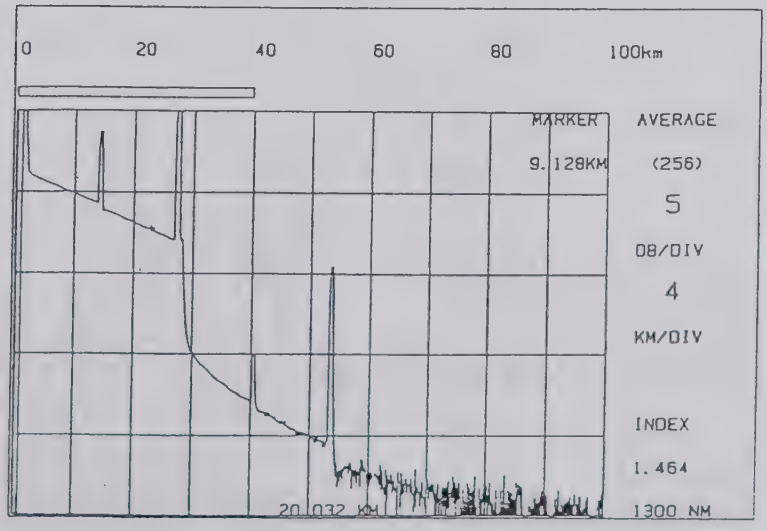


Figure 3-13. 100km Distance Range.

13.02 When a fiber signature is stored by averaging in the Hi Res mode, 12.5 km (7.75 kft) of the signature is held by the instrument at one time (beginning at the left edge of the display window when the averaging process is initiated). After averaging has been initiated, display window movements are limited to within this stored section.

13.03 A fiber signature at one wavelength can be alternately examined in normal and high resolution modes, by using the following procedure:

1. Set the display window as desired on the fiber signature.

2. Press Hi Res to set the Model 3100H on high resolution mode.

3. Press Avg to average and store the Hi Res signature.

4. When averaging is complete, press Hi Res again (Hi Res will not respond before averaging is complete). The Model 3100H returns to normal resolution but the separate Hi Res memory is retained.

5. Without moving the display window, press Avg to repeat the averaging process with Hi Res off.

6. Toggle the display between the two modes by pressing the Hi Res button. Measurements can be performed in either mode.

13.04 This procedure can be performed in the opposite sequence (normal resolution first), providing that the feature of interest is in the data acquisition segment for Hi Res.

14. PLOTTER OUTPUT

14.01 If a plotter is connected to the GPIB interface and the address switches are set to "31" (refer to Section 4, GPIB), the display may be plotted at any time by pressing the Plot button. To abort the plotting routine, press the Local button.

15. CHANGING THE FUSE

15.01 To replace a fuse, use the following procedure:

1. Disconnect the power cord.

DANGER: Failure to disconnect the power cord before changing the fuse can result in an electrical shock.

2. Refer to Figure 3-14, Rear Panel. Locate the input fuse holder and line voltage selection cover on the rear panel. Open the cover using a small blade screwdriver or similar device. Remove the fuse block.

3. Remove the fuse and replace it with the following:

105-125 Volt: UL 198.6 (3AG) 1/4x1 1/4
250 Volt: 3 Amp Slow Blow
220-240 Volt: IEC 127 5x20 mm 250V 2.5A (T)

4. Replace the fuse block assembly. Reconnect the power cord.

CAUTION: Repeated fuse blowing indicates a potentially serious problem. Be sure you are using the correct fuse value, have selected correct line voltage, and have a properly wired AC source. Contact Photon Kinetics if the problem persists.

16. CHANGING THE LINE VOLTAGE

16.01 Use the following procedure to change the line voltage to one of the following four voltages: 100V, 120V, 220V, 240V.

1. Disconnect the power cord.

DANGER: Failure to disconnect the power cord before changing the line voltage can result in an electrical shock.

2. Refer to Figure 3-14, Rear Panel. Locate the input fuse holder and line voltage selection cover on the rear panel. Open the cover using a small blade screwdriver or similar device.

3. Refer to Figure 3-15, Input Voltage Selector Removal/Installation. Using a small needle nose pliers, pull the voltage selector card straight out of housing.

Figure 3-14. Rear Panel.

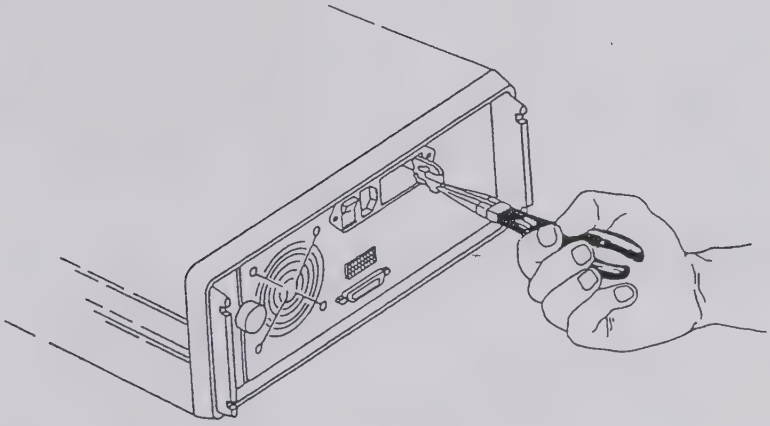


Figure 3-15. Input Voltage Selector Removal/Installation.

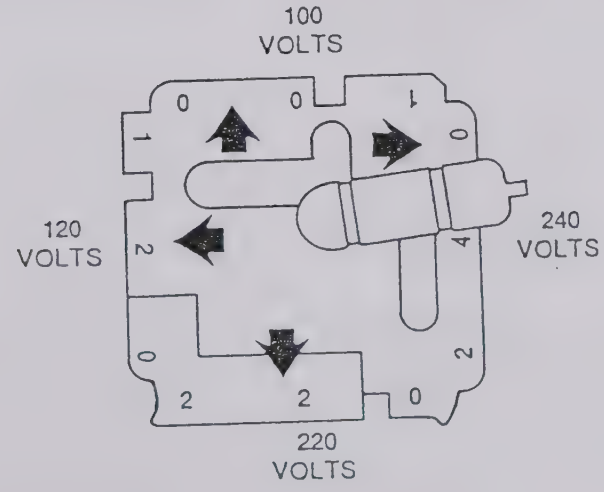


Figure 3-16. Input Voltage Selector Orientation.

4. Refer to Figure 3-16, Voltage Selector Orientation. Turn the voltage selector card so that the desired voltage as printed on the card will be the end reinserted into the housing. Slide the indicator pin through the cutouts to the side opposite the selected voltage.

5. Reinsert the voltage selector card. It should be oriented so that the printed side faces the power switch, and so that the arrow on the card pointing to the desired voltage is the end inserted first.

6. Replace the fuse holder assembly and assembly cover. Verify that the indicator pin shows the desired voltage.

17. INSTALLING AN OPTICAL PLUG-IN

17.01 Refer to Figure 3-14, Rear Panel, while performing the following procedures.

1. Turn off the Model 3100H.

CAUTION: Removing or installing an optical plug-in with power applied will damage the unit.

2. Unscrew the optical connector dust cap.

3. Unscrew and remove the retaining screw at the rear of the chassis

4. Grasp the handle on the rear of the plug-in, and pull straight out. The module should slide easily out of the Model 3100H mainframe. Immediately install a clean dust cap on the module's optical connector.

5. Remove the dust cap from the replacement plug-in. Insert the plug-in into the Model 3100H mainframe so that the optical connector faces the inside of the mainframe and will go through the hole in the front panel.

6. Gently slide the plug-in into the mainframe straight on. Resistance will be felt as the electrical connector on the plug-in begins to seat in the chassis connector.

7. Push the plug-in firmly into place.

8. Reinstall the retaining screw. Gently but firmly tighten the knob. This properly seats the electrical connector and locks down the optical plug-in.

9. Replace the optical connector dust cap on the newly installed unit.

NOTE: If the replacement plug-in has a different type of optical connector, it may be necessary to change the dust cap as well. To do so, follow the cap chain back to the chassis and remove the screw that anchors the chain. Remove the old dust cap and chain and in its place install a suitable dust cap and chain.

NOTE: If the plug-in is a 628H dual wavelength, the rear panel switch setting can be set either to 1300 nm, 1550 nm or "selectable", which allows the Wavelength button on the front panel to control the wavelength.There is a lock on the selector switch that locks it in the selectable position. Unscrew the lock and store it if you do not wish to lock the switch in this position.

CAUTION: Failure to place a dust cap on the optical connector when not in use can seriously degrade the performance of the connector.

SECTION 4: GPIB INTERFACE

1. OVERVIEW

1.01 This section describes the GPIB interface to the Model 3100H. A GPIB connection allows the Model 3100H to be connected to a plotter or to use an external computer to perform an automated measurement sequence. Acquired data can also be downloaded from the instrument. The Model 3100H GPIB interface is IEEE Standard 488.

1.02 The program, whatever the programming language, must include the correct commands to send and receive data from the Model 3100H. No instruction is given in this chapter regarding programming, but each legal command is listed with all its options. Two small programs are included at the end of this section as examples.

2. GPIB HARDWARE

2.01 The Model 3100H connects to any computer that uses an IEEE Standard 488 GPIB interface. The 24-pin cable connects to the rear of the Model 3100H (see Figure 4-1) and the dip switch settings are adjacent. The address setting on the back of the Model 3100H and the HPGL plotter must agree with the setting specified in the computer program.

GPIB Address and Switch Block Description

2.02 Five switches set the GPIB address of the Model 3100H: 1, 2, 4, 8, 16 and A (switches 1-6 from the left). These are binary coded address switches, which means that the switch values are added together to obtain the desired address. For example, the plotter requires address 31: 16+8+4+2+1=31 – all of the switches are on. If address 17 is required, select 16+1=17 (10001 binary). The address selection can be verified by pressing the Local button. The decimal value of the switch address settings will appear in the bottom left corner of display.

2.03 The "A" switch selects the GPIB command line terminator: line feed (set to 0) or EOI ("End of line" - set to

2.04 Switch block switches B and M/FT are not part of the GPIB address. "B" selects the power-up default splice loss operation: auto (set to 0) or manual (set to 1). "M/FT" selects distance measurement units: feet (set to 0) or meters (set to 1). Figure 4-2 illustrates the GPIB address and switch block.

3. GPIB COMMUNICATIONS

3.01 The following section provides the various GPIB communication formats and protocols. These examples must be followed exactly in order for the Model 3100H to communicate with the computer.

Input Messages

3.02 Remote control messages to Model 3100H are of two types:

1. Commands that the Model 3100H receives as control data
2. Queries that request the Model 3100H to send output data

3.03 Messages contain ASCII characters. The Model 3100H accepts either upper or lower-case characters for the mnemonics shown in the examples.

a) Message terminator (TERM) The active terminator is selected by the rear-panel switch "A". The end-of-message terminator may be either:

1. The END message (EOI asserted concurrently with the last data byte)
2. The ASCII code for line feed (LF) sent as the last data byte

b) Input and Execution The Model 3100H remains busy until the command is executed. While busy, further input is not accepted.

c) Arguments Numeric arguments can be integers, floating point decimals, or floating point decimals in scientific notation (E).

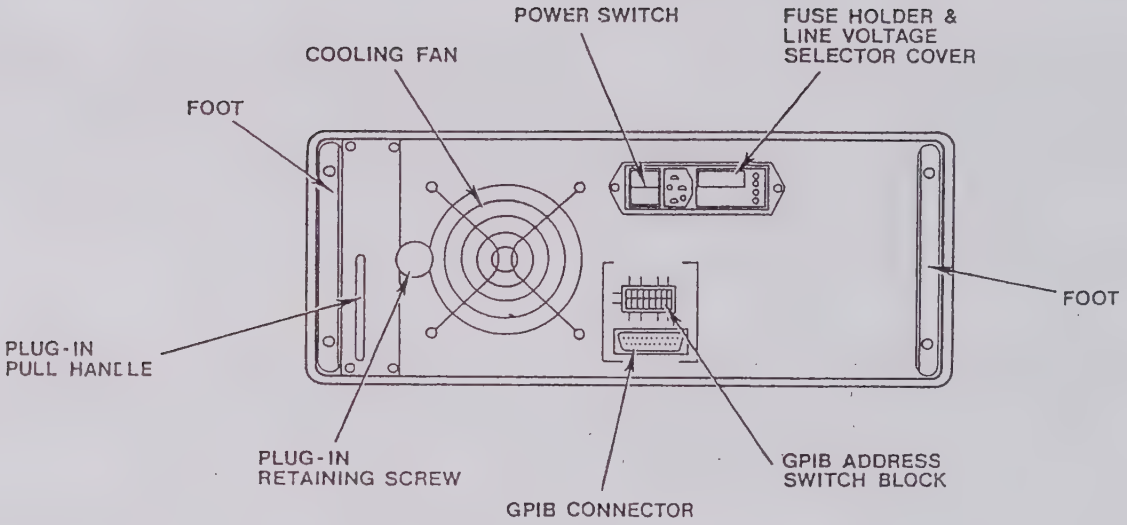


Figure 4-1. Rear Panel.

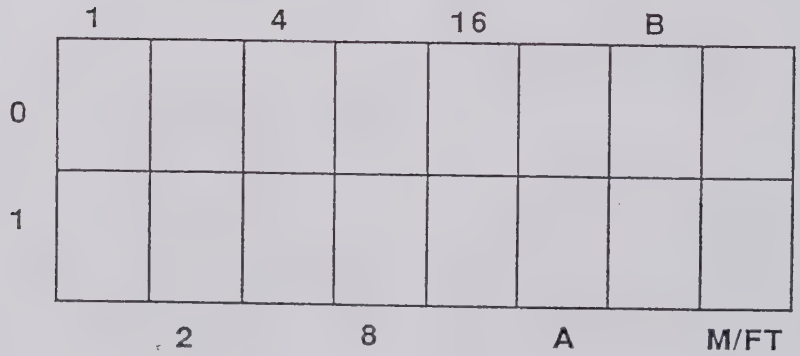


Figure 4-2. GPIB Address and Switch Block.

If the number exceeds the range of the function, the Model 3100H does not execute the command, but issues an error. Numbers within the range are rounded. In some cases a number may be used instead of ON (1) or OFF (0).

3.05 Words or mnemonics may also be used as arguments. ON and OFF, for instance, are arguments for the commands that correspond to certain Model 3100H front-panel push buttons.

Output Messages

3.06 When the Model 3100H receives a query, it sends an output message that is a response to the query. Output messages contain ASCII characters (except when a binary waveform is requested).

3.07 The instrument begins output when talked; it continues until it reaches the end of the information or is interrupted by a device clear, untalk, or interface clear message. If not interrupted, the instrument terminates the output according to the setting of the EOI or LF switch.

4. GPIB COMMANDS AND QUERIES

4.01 The front panel can be controlled through the GPIB interface, with the exception of Power and Intensity. These two must be controlled from the instrument.

4.02 The following commands control axis and scale factors:

- DBDIV
- DIST
- KMDIV
- VRTPOS

4.03 The following commands control fiber specifications and measurement:

- DELTA
- HI RES
- MEAS
- MARKER
- RANGE
- REF
- RMS
- SPLOSS
- WAVELENGTH

4.04 The following commands control transfer of data:

- ACURVE
- BCURVE
- PLOT

4.05 These commands control system functions:

- EOA
- ID
- INIT
- LCL
- LOCK
- RQS
- UNLOCK

4.06 Commands and queries are listed alphabetically. Only the first three letters of the command or query are needed. These letters are capitalized in the example. When specific numbers or characters are needed, this is indicated by placing the representative word in brackets, i.e. [argument], [value], [LOSS]. A space between characters is indicated by a "¬".

5. ACURVE (send ASCII waveform)

5.01 Query: ACUrve?
Response: [X-start¬Delta¬Count¬Data%]
Example: 0¬.05¬801¬22.43...%

5.02 This query asks the Model 3100H to send an ASCII waveform to the computer. X-Start is the x-coordinate in kilometers for the first curve value. Delta is the distance in kilometers between curve values. Count is the number of points. Data is the y-coordinate in dB above the lower clip point. The linear distances X-Start and Delta both assume a reference index of 1.499. See Figure 3-3 for a diagram.

6. BCURVE (send binary waveform)

6.01 Query: BCUrve?
Response: [%¬X-start¬Delta¬Binary¬Count¬Checksum]

6.02 This command asks the Model 3100H to send a binary waveform to the computer. The example would be a string of ones and zeros. See Figure 3-4 for a diagram.

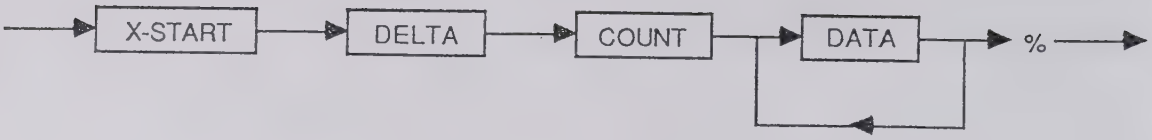


Figure 4-3. ACURVE Diagram.

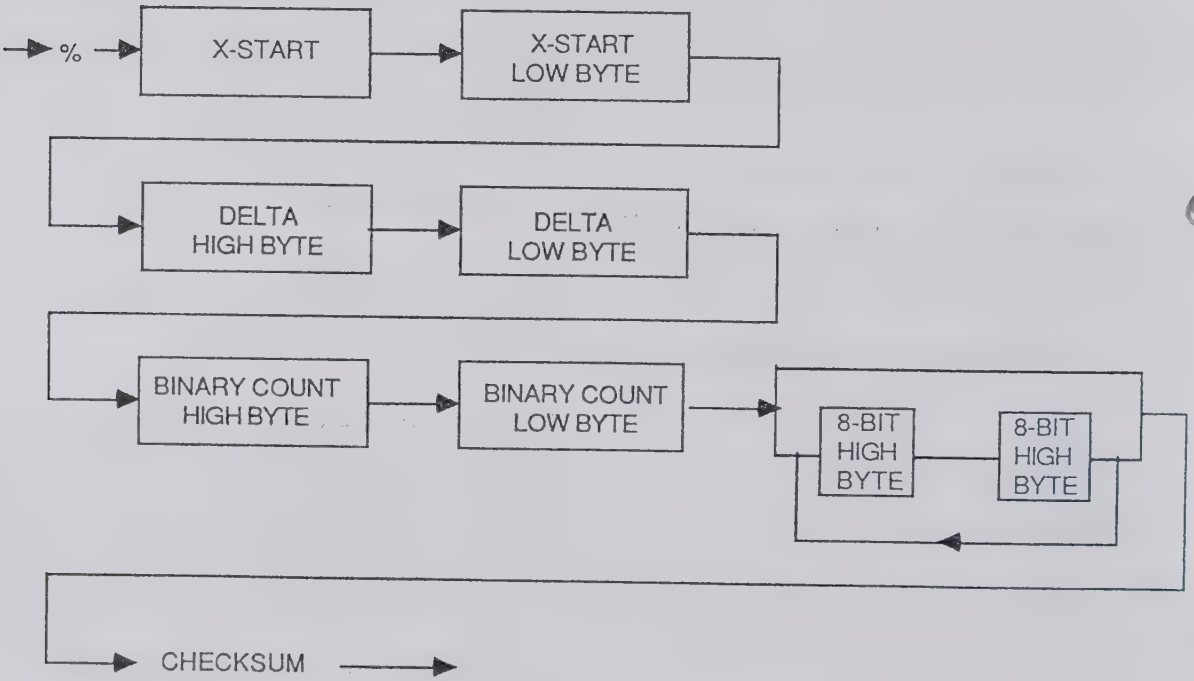


Figure 4-4. BCURVE Diagram.

The data is a sequence of binary numbers, preceded by the ASCII code for "%" and three two-byte binary integers representing the start-coordinate in tens of meters (X-start), the distance between points in tens of meters (Delta) and the number of binary numbers plus one (Count - the extra byte being the checksum) and followed by the checksum.

6.04 The checksum is the 2's complement of the modulo-256 sum of all preceding bytes except the first ("%"). Thus the modulo-256 sum of all bytes except the first ("%") should equal zero – providing an error-check of the binary block transfer.

6.05 The linear distances X-Start and Delta both assume a refractive index of 1.499. The BCURVE values are given in screen units. These are 250 screen units/div. The bottom of the display is at 100 and the top is at 1350.

7. DBDIV (vertical scale factor)

7.01 Command: DBDiv¬[argument]
Example: DBDiv¬0.5

The argument can be a number, or the ASCII characters "INC", "DEC", or "MAX". A number selects the vertical scale factor (0.5, 1 or 5 dB/div). Numbers other than these three are rounded to the nearest step. INC selects the next larger scale factor in the front panel 0.5-1-5 sequence, if possible. If the instrument defaults to 5 dB, a range warning error is issued. DEC selects the next smaller scale factor in the front-panel 0.5-1-5 sequence, if possible. If the instrument defaults to 0.5 dB, a range warning error is issued. MAX selects the maximum vertical scale factor.

7.03 Query: DBDiv?
Response: DBDIV¬[value]
Example: DBDIV¬5

7.04 The value will be 0.5, 1 or 5 dB, representing the vertical scale factor.

8. DELTA (delta mode)

8.01 Command: DELta¬[argument]
Example: DELta¬ON

The argument can be either "ON", "OFF" or the numbers 1 or 0. ON selects delta mode. OFF selects the normal mode. 1 equals ON; 0 equals OFF. Other numbers are rounded to 1 or 0.

9. DIST (center horizontal position)

9.01 Command: DISt¬[value] Example: DISt¬20.238

9.02 This command centers the waveform at the value specified. The value must be the center value in kilometers. If the value defaults to max or min values according to the range of data in memory, a range warning error is issued. The value is rounded to the nearest 50 m in normal mode, or to the nearest 12.5 m in high resolution mode.

9.03 Query: DISt? Response: DIST¬[value]
Example: DIST¬20.238

9.04 The value will be the center position in kilometers, in floating point decimal form.

10. EOA (end-of-acquisition)

10.01 Command: EOA¬[argument] Example: EOA¬OFF

10.02 The argument can be either "ON", "OFF" or the numbers 1 or 0. ON causes the instrument to assert SRQ when an acquisition completes. OFF causes the instrument not to assert SRQ for the EOA condition. 1 equals ON; 0 equals OFF. Other numbers are rounded to 1 or 0. The default is OFF. Interaction is always OFF in talk-only modes.

10.03 Query: EOA? Response: EOA¬[argument]
Example: EOA¬1

10.04 The argument options are the same as for the command.

11. HIRES (high resolution)

11.01 Command: HIRes¬[argument]
Example: HIRes¬ON

11.02 The argument can be "ON", "OFF" or their numerical equivalents. ON selects the high-resolution mode. OFF selects the normal-resolution mode. 1 equals ON; 0 equals OFF. Other numbers are rounded to 1 or 0.

11.03 Query: HIRes? Response: HIRES¬[argument]
Example: HIRES¬ON

12. ID (identify)

12.01 Query: ID? Response: ID¬[PK version, unit]
Examples: PK¬2.2¬1300
PK¬2.2¬1550¬628H

12.02 The values are the instrument firmware version number, the plug-in wavelength and the plug-in unit number, if the plug-in is a 313L, 313M, or a 628H in switchable mode.

13. INIT (initialize settings)

13.01 Command: INIt

13.02 INIT resets the instrument in the same manner as turning the power off, then turning it back on. These functions are reset to:

Function	INIT Value
VRTPOS	5 dB
DBDIV	5dB/div
DIST	20km
KMDIV	4km/div
HIRES	OFF
MEAS	FREE RUN
MARKER	On curve at 20,000m
EOA	OFF
RQS	OFF
DELTA	OFF

14. KMDIV (horizontal scale factor)

14.01 Command: KMDiv¬[argument]
Example: KMDiv¬INC

14.02 The argument can be a number, or the ASCII characters "INC", "DEC", or "MAX". A number selects the horizontal scale factor. Numbers not in the front panel sequence are rounded to the nearest step. Front-panel sequence normal mode: 0.2, 0.5, 1, 2, 4 km/div. Front-panel sequence hi-res mode: 0.05, 0.1, 0.2, 0.5, 1 km/div. INC selects the next larger horizontal scale factor in the front-panel sequence, if possible. If the instrument defaults to MAX, a range warning error is issued. DEC selects the next smaller scale factor in the front-panel sequence, if possible. If the instrument defaults to MIN, a range warning error is issued. MAX selects the maximum horizontal scale factor.

14.03 Query: KMDiv? Response: KMDIV¬[value]
Example: KMDIV¬0.1

14.04 The value will be the horizontal scale factor in kilometers/div.

15. LCL (local)

15.01 Command: LCL

15.02 This command returns control of the Model 3100H to the front panel.

16. LOCK (lock front panel)

16.01 Command: LOCK

16.02 This command locks out the Local button on the front panel. The inverse command is UNLOCK.

17. MARKER (set marker)

17.01 Command: MARker¬[argument] Example: MARker¬13.556

17.02 This command positions the marker at the value specified. The argument is the horizontal marker value in kilometers. If the value defaults to max or min values according to the range of the data on the screen, a range warning error is issued.

17.03 Query: MARker?
Response: MARKER¬[value,¬value]
Example: MARKER¬14.58,¬2.5

17.04 The values are the marker x-coordinate in kilometers, and the marker y-coordinate in dB above the lower clip level. If the vertical position of the marker is outside the viewing area, the y-coordinate defaults to the position of the top or bottom of the screen.

18. MEAS (select measurement mode)

18.01 Command: MEAs¬[argument]
Example: MEAs¬AVG

18.02 The argument can be an integer or one of two codes: "FREERUN", "AVG". FREERUN selects free-run mode. AVG selects average-and-store mode. The inte

e represents the total number of averaging cycles. Values are rounded to the nearest integer in the range from 1 to 256.

18.03 Query: MEAs? Response: MEAS¬[argument] Examples: MEAS¬FREERUN, MEAS¬136

18.04 The response will be either "FREERUN" or the number of averages done.

19. PLOT (plot data)

19.01 Command: PLOT

19.02 This command plots the Model 3100H screen on a GPIB plotter using the HPGL language.

19.03 Note: to plot splice loss, the command sequence must be:

PLOT¬ON
SPL?
PLOT¬OFF

RANGE (fiber length range)

20.01 Command: RANge¬[argument]
Example: RANge¬50

20.02 This command sets the fiber distance range. Valid values are 50 and 100 (km). The number is rounded to the nearest value.

20.03 Query: RANge? Response: RANGE¬[value] Example: RANGE¬100

20.04 The value is the distance range in kilometers.

21. REF (refractive index)

21.01 Command: REF¬[argument]
Example: REF¬1.464

21.02 This command sets the refractive index to the value specified. The argument will be a number, with the valid range from 1.4 to 1.7. If the value is invalid or outside of the range, a range warning error is issued.

21.03 Query: REF? Response: REF¬[value]
mple: REF¬1.458

21.04 The value will be the refractive index in floating point decimal format.

22. RMS (rms noise)

22.01 Command: RMS

22.02 This command forces a measurement of the rms noise level of the system. This can only be done when the Model 3100H is in free run mode.

22.03 Query: RMS? Response: RMS¬[value] Example: RMS¬14.80

22.04 The value will be the RMS noise level in floating point decimal format. This is the unaveraged rms noise level in one-way optical dB units above the display's lower clip level.

23. RQS (request service)

23.01 Command: RQS¬[argument] Example: RQS¬ON

23.02 The argument must be "ON", "OFF" or their numerical equivalents. ON causes SRQ is to be asserted when abnormal status conditions occur. OFF causes SRQ to be not asserted (masked) when abnormal status occurs. RQS OFF does not affect whether SRQ occurs at the end of an acquisition – see EOA. 1 equals ON; 0 equals OFF. Other numbers are rounded to 1 or 0. The default is ON. Interaction is always OFF in talk-only modes.

23.04 Query: RQS? Response: RQS¬[argument] Examples: RQS¬OFF, RQS¬0

23.05 The argument options are the same as for the command.

24. SPLOSS (splice loss)

24.01 Query: SPloss?
Response:SPLOSS¬[Y/N¬Position¬Loss¬Error]
Example: SPLOSS¬Y¬4.28¬.11 .01.

24.02 This query forces an AUTO splice loss measurement at the current marker position and reports the results. The first value will be a "Y" if a splice was detected and an "N" if a splice was not detected. The second value, position, is the real position of the splice in km if (1) is Y; the marker position if (1) is N. The third value, loss, is the real splice loss in dB (floating point decimal format). The last value, loss error, is the real statistical error in the splice loss in dB (floating point decimal format).

25. UNLOCK (unlock front panel)

25.01 Command: UNLock

25.02 This command unlocks the Local button on the front panel. The inverse command is LOCK.

26. VRTPOS (vertical position)

26.01 Command: VRTpos¬[argument] Example: VRTpos¬5.38

26.02 This command positions the clip-level to the value specified relative to the bottom of the screen. The argument must be a number, or the ASCII characters "INC" or "DEC".

26.03 A number must be within the range possible with the DBDIV setting. If the value defaults to max or min values according to the DBDIV setting, a range warning error is issued. The value is rounded to the nearest 0.02 dB in 5 dB/division, and 0.01 dB/division in the other vertical scales.

26.04 INC moves the waveform up by one step relative to the bottom of the screen. If the value defaults to max or min according to the DBDIV setting, a range warning error is issued. The step value is determined by the value of DBDIV. (DBDIV/5)

26.05 DEC moves the waveform down by one step relative to the bottom of the screen. If the value defaults to max or min according to the DBDIV setting, a range warning error is issued. The step value is determined by the value of DBDIV. (DBDIV/5)

26.06 Query: VRTpos? Response: VRTPOS¬[value] Example: VRTPOS¬5.6

26.07 The response returns vertical position value of the clip-level in dB relative to the bottom of the screen, in a floating point decimal format.

27. WAVELENGTH (plug-in wavelength)

27.01 Command: WAVelength¬[value]
Example: WAVelength 1300

27.02 This command sets the plug-in wavelength, if the plug-in is a 628H and the rear panel switch is set to the middle (switchable) setting.

27.03 Query: WAVelength?
Response:WAVELENGTH¬[value]¬[unit number]
Example: WAVELENGTH¬1300¬313M

The response is the plug-in wavelength. If the plug-in is a 313L, 313M or a 628H in switchable mode, the response also includes the plug-in unit number.

28. SERIAL POLL

28.01 The system also responds to the standard GPIB serial poll. The returned values are shown below in Tables 4-1 and 4-2:

Table 4-1. Serial Poll Results.

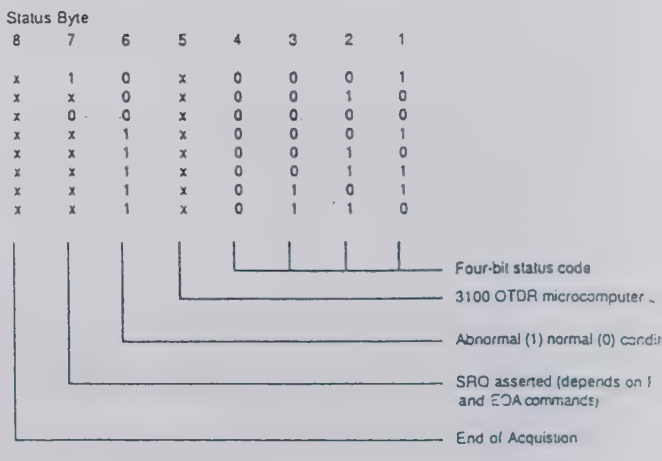

Status Byte
8 7 6 5 4 3 2 1
x 1 0 x 0 0 0 1
x x 0 x 0 0 1 0
x 0 0 x 0 0 0 0
x x 1 x 0 0 0 1
x x 1 x 0 0 1 0
x x 1 x 0 0 1 1
x x 1 x 0 1 0 1
x x 1 x 0 1 1 0
Four-bit status code
3100 OTDR microcomputer
Abnormal (1) normal (0) condi
SRQ asserted (depends on
and EOA commands)
End of Acquistion

Table 4-2. Status Codes.

Normal Status Code	
0	Normal Operation
1	Range Warning
2	Real Error
3	Command Error
4	Query Error
5	Argument Error
15	Plot Active

Abnormal Status Code	
16-17	Hardware (Waveform processor)
18	Hardware (Display Memory)
19	Software (Model 3100H)

28. SAMPLE PROGRAMS

28.01 The following programs have been written in HP BASIC, version 3.01. The GPIB address of the OTDR must be "23", the plotter "5". Also, GPIB switch "A" must be set to "0" (line feed terminator).

28.02 The following program queries the OTDR for the current setting of the horizontal scale factor, and prints the value on the screen.

```
10  OUTPUT 723; "KMD?"
20  ENTER 723; A$
30  PRINT A$
40  END
```

Note that any query or command could be sent in place of "KMD?" (for example "SPL?"). Only a query would elicit a print response from the OTDR, however.

The following program does a plot of the current screen:

```
10  ASSIGN @PLOT TO 723, 705
20  OUTPUT 723; "PLOT"
30  REPEAT
40  ENTER @PLOT
50  UNTIL (SPOLL (723) MOD 16) <> 15
60  END
```

28.03 This prints all screens except the splice loss screen; you must use PLOT ON, PLOT OFF commands for a splice loss plot.

Appendix A:
Model 3100H Specifications

3100H GUARANTEED SPECIFICATIONS

Wavelength	1310±20nm		1530±30nm	
Pulse Width	2500ns(250m)	500ns (50m)	2500ns (250m)	500ns (50m)
Backscatter Range (one way SNR = 1)	21dB	16dB	18.5dB	13.5dB
Fresnel Range (one way SNR = 1)	36dB	34.5dB	34.5dB	33.0dB
Data Acquisition Window	50km	12.5km	50km	12.5km
Distance Measurement Accuracy	.01%±25m	.01%±12m	.01%±25m	.01%±12m
Distance Ranges	50km or 100km switch selectable			
Readout Resolution	1m or 1ft			
Refractive Index Range	1.400 to 1.700			
Horizontal Scale	2500ns pulse 4000, 2000, 1000, 500, 200 m/div 500ns pulse 1000, 500, 200, 100, 50 m/div			
Time to Average	50km 100km	52 seconds 104 seconds		
Free Run Rate	50km 100km	5 waveforms per second 2.5 waveforms per second		
dB Scale Accuracy	.05db per dB			
dB Readout Resolution	.01dB			
Vertical Scales	5,1,0.5 dB/div			
Display	6 inch diagonal			
Plotter Output	in HPGL format			
GPIB IEEE-488	talker/listener capability			
Connector Type	FC, D4, Diamond, contacting Biconic, polished back Biconic (reduces measurement range by one dB)			

ENVIRONMENTAL SPECIFICATIONS

Operating Temp	+5°F to +131°F (-15°C to +55°C)
Non-operating Temp	-40°F to +167°F (-40°C to 75°C)
Shock	30g, 11msec half-sine, six directions
Vibration	5 to 55 Hz, .025 inches peak-peak amplitude
EMI	within MIL Std 461 limits for conducted and radiated emissions
Input Voltage	90 to 132 V or 180 to 264 V, 48 to 63Hz
Input Power	105 watts, 126 VA typical (115V, 60Hz) 120 watts max

CERTIFICATION

Safety	UL 1244, CSA
Laser	Class 1 CFR 21
Weight	33 lbs. (16 kg)
Dimensions	7.1 x 16.4 x 20.8 inches (18.1 x 41.6 x 52.8 cm) including front covers

APPENDIX B:
Offset Adjustment for the Model 3100T

The Model 3100T has been optimized for noise reduction at approximately 60km (for 1300nm) or 80km (for 1550nm), but occasionally certain conditions may require a slightly different optimization. For this reason, an adjustment knob is located on the rear of each plug in, just above the handle. This knob has been locked down at the factory, and should require no adjustment as long as the plug-in remains in the same mainframe. See Figure 1 below for an example of a fiber signature optimized at 60km.

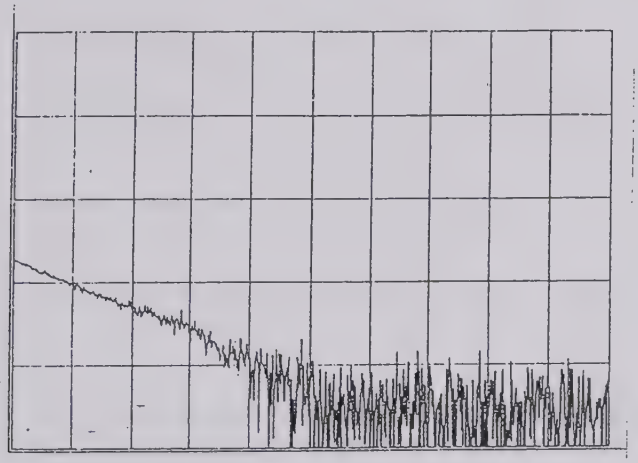


Figure 1. Fiber Signature Optimized at 60km.

There are a few cases in which the 3100T might need to be adjusted. If the plug-in is switched to another mainframe, if extreme environmental conditions exist, or the 3100T is measuring a very long fiber with a lot of reflective splices, the usual fiber signature might be replaced with one that dips into the noise, then bounces back up (see Figure 2 below). In this case, the knob must be adjusted slightly before a measurement is made.

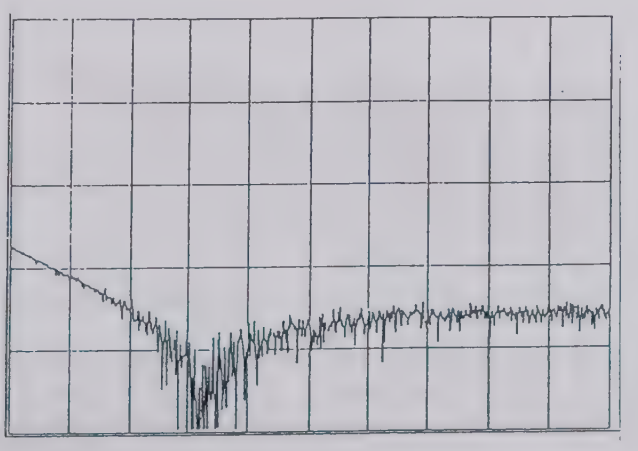


Figure 2. Non-optimized Fiber with "Bounce-back" in Signature.

In another instance, when the fiber signature does not end in the usual noise pattern, but remains high and very thin (see Figure 3 below), the knob needs to be adjusted slightly in the other direction.

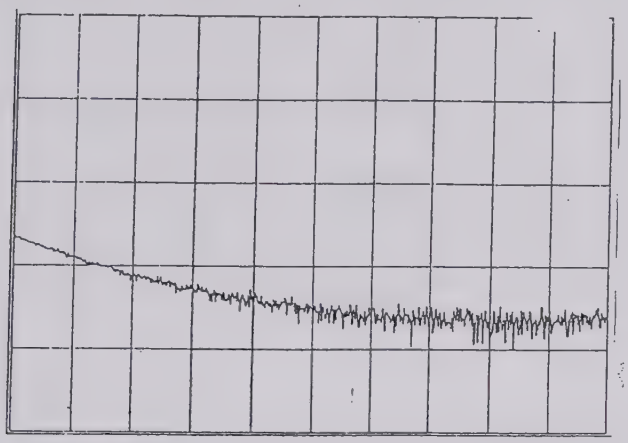


Figure 3. Non-optimized Fiber with No Noise Signal.

To adjust knob:

1) Center the signature so that the point at which it first dips into the noise is in the middle of the screen.
2) Unlock the adjustment knob, using the 5/16" wrench supplied with the mainframe.
3) Push the Free Run button, and turn the knob SLIGHTLY until the noise portion of the signature is very thick and dense (see Figure 4 below).

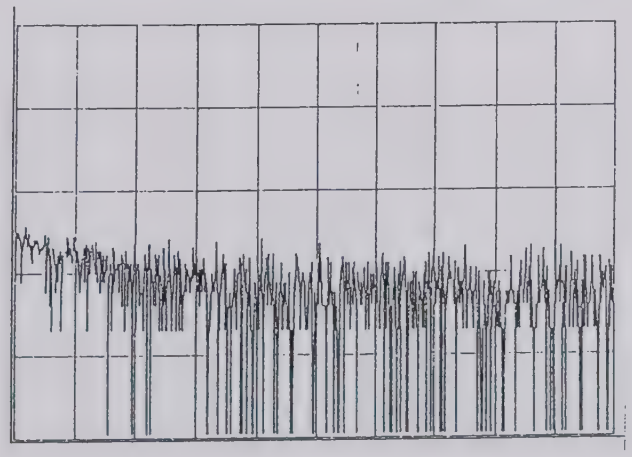


Figure 4. Unaveraged Signature with Optimum Density.

4) Push the Average button and watch as the signature is averaged. If, by 50 averages, the noise portion is still very thick, with many spikes approximately one division wide (at 5 dB/div), then the adjustment has been made. If the noise portion thins out and the long spikes disappear, a further adjustment must be made. Repeat step 3 in this case.
5) The adjustment knob does not have to be locked, but it is susceptible to being bumped if it is in the unlocked position.

Appendix C:
Model 3100 T Specifications

Model 3100T Long Range Single-Mode OTDR

PK offers the longest range OTDR in the world. This instrument is specially designed for undersea cables where runs are extremely long, splices are far apart, and the distance between regenerations is the greatest possible. Offering up to 28dB range at 1310nm and 25.5dB at 1530nm, the wavelengths are available in separate plug-ins. This unit is rugged and highly portable.

3100T GUARANTEED SPECIFICATIONS

Wavelength	1310±20nm		1530±30nm	
Pulse Width	10us(1km)	1us(100m)	10us(1km)	1us(100m)
Backscatter Range (one way SNR = 1)	26.0dB	18.0dB	23.5dB	15.5dB
Typical	28.0dB	20.0dB	25.5dB	17.5dB
Fresnel Range (one way SNR=1)	38.0dB	36.5dB	36.5dB	35.0dB
Typical	40.0dB	38.5dB	38.5dB	37.0dB
Data Acquisition Window	50km	12.5km	50km	12.5km
Distance Measurement Accuracy	.01%±35m	.01%±20m	.01%±35m	.01%±20m
Distance Ranges	50km or 100km switch selectable			
Readout Resolution	1m or 1 ft.			
Refractive Index Range	1.400 to 1.700			
Horizontal Scales	10us pulse 4000,2000,1000,500,200 m/div 1us pulse 1000,500,200,100,50 m/div			
Time to Average	50km 100km	52 sec 104 sec		
Free Run Rate	50km 100km	5 waveforms per sec 2.5 waveforms per sec		
dB Scale Accuracy	.05dB per dB			
dB Readout Resolution	.01dB			
Vertical Scales	5,1,0.5dB/div			
Display	6 inch diagonal			
Plotter Output	in HP GL format			
GPIB IEEE-488	talker/listener capability			
Connector Type	FC, D4, Diamond, contacting Biconic, polished back Biconic (reduces measurement range by one dB)			

ENVIRONMENTAL SPECIFICATIONS

Operating Temperature	+5° F to + 131°F (-15°C to +55°C)
Non-operating Temperature	-40° F to + 167° F (-40°C to +75°C)
Shock	30g, 11 msec half-sine, six directions
Vibration	5 to 55 Hz, .025 inches peak-peak amplitude
EMI	within MIL Std 461 limits for conducted and radiated emissions
Input Voltage	90 to 132 V or 180 to 264 V, 48 to 63 Hz
Input Power	105 watts, 126 VA typical (115 V, 60 Hz) 120 watts max

CERTIFICATION

Laser	Class 1 CFR 21
Weight	33 lbs. (15 kg)
Dimensions	7.1 x 16.4 x 20.8 inches (18.1 x 41.6 x 52.8 cm) including front cover

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Power

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